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MINERALOGICAL ABSTRACTS

EDITED BY L. J. SPENCER, F.R.S.

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THE MINERALOGICAL MAGAZINE

AND

JOURNAL OF THE MINERALOGICAL SOCIETY.

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Vol. XXI.

Biographical notices of mineralogists recently deceased. (Third series.)¹

By L. J. SPENCER, M.A., Sc.D., F.R.S.

Assistant-Keeper in the Mineral Department of the British Museum
(Natural History).

[Communicated March 15, 1927.]

IN the following list of 42 lives, with a range in ages from 24 to 97 years, the average age is 68 years. In previous lists of 303 lives the average age was 64 at death.

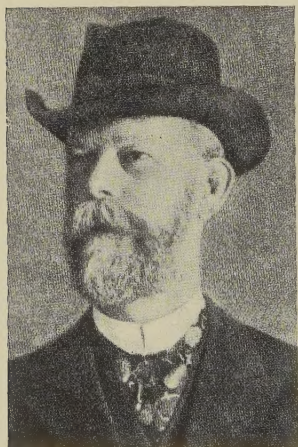
BALLY-PRIOR (Eduard) [1847-1926], a private collector of minerals, was born, Peter Eduard Bally, at Schönenwerd in canton Aargau, Switzerland, on August 11, 1847, married Marie Prior in 1874, and died on July 24, 1926. He had collected for sixty years, and, having a prosperous boot-manufacturing business, he was able to buy the best specimens. The collection is well installed in a special building, the E. Bally-Prior Museum, at Schönenwerd, which was presented to the canton shortly before his death and is open to the public. The

¹ Series I and II in Min. Mag., 1921, vol. 19, pp. 240-259; 1924, vol. 20, pp. 252-275. An index to earlier notices in vols. 1-19 was given in vol. 19, pp. 259-262. Professor P. N. Chirvinský of Novoherkassk has again very kindly given much information for the notes on Russian mineralogists; I have also to thank Dr. George F. Kunz of New York and Professor F. Slavík of Prague for help.

mineral collection, a general one, is specially rich in Swiss minerals, with good series from the Simplon tunnel; and there is a specially fine display of chessylite and malachite. A good collection of meteorites contains representatives of 69 falls with a total weight of 70,100 gm. of material, including a large (6,690 gm.) etched slice of the Mukerop iron. Guide-books to the mineral and the meteorite collections have been issued. (*Centralblatt Min., Abt. A*, 1926, pp. 271-272; portrait in *Schweiz. Min. Petr. Mitt.*, 1926, vol. 6.)

BAUHANS (Hans) [1888-1918] was born at Mannheim in Germany on October 4, 1888, and was killed in the war on March 27, 1918.¹ He studied at Heidelberg under Prof. V. Goldschmidt, to whom he was afterwards assistant. The results of his experiments on the etching and solution of alum crystals, when he obtained forms closely resembling those of diamond, were published in 1914. Later papers (in 1918 and 1924) with V. Goldschmidt dealt with the vectorial solution velocity of fluorite. (V. Goldschmidt, *Beitr. Kryst. Min.*, 1924, vol. 2, pp. 178-181, with portrait.)

BAUMHAUER (Heinrich Adolf) [1848-1926], since 1896 Professor of Mineralogy in the University of Freiburg in Switzerland, was born at Bonn in Germany on October 26, 1848, and died at Freiburg on August 1, 1926. He graduated at Bonn in 1869 and studied also at Göttingen in 1870-1. After teaching in the Technical Schools at Frankenburg in Saxony and at Hildesheim, he was from 1873 teacher in chemistry in the Agricultural School at Lüdinghausen in Westphalia, where he remained for twenty-three years. For some years at Freiburg he was Professor of Inorganic Chemistry as well as of Mineralogy and Crystallography. His elementary textbooks on inorganic chemistry, organic chemistry, mineralogy, and crystallography each passed through several editions, that on inorganic chemistry reaching a seventh



H. BAUMHAUER.

edition in 1916. Some of his early papers were chemical, but his real in-

¹ *Beitr. Kryst. Min.*, 1924, vol. 2, p. 181; but on p. 123 of the same volume and part the date of death is given as March 17, 1917.

terest evidently was in crystallography, and he was the author of a number of sound papers on the crystallography and optics of various minerals and chemical compounds. His earlier research work was done in his spare time, apparently under rather difficult conditions, and his results did not at first meet with ready acceptance. He commenced the study of etch-figures on crystals in 1869, and on this subject he produced a useful monograph in 1894. The minerals of the Binnenthal in Switzerland also claimed his attention, and from there he described as new species rathite (named in memory of his former teacher G. vom Rath), seligmannite, and arsenoferrite, whilst another was named baumbauerite after him. The rich development of faces on some of the Binnenthal crystals led him to the study of the grouping of crystal-faces in zones, a subject on which he wrote several papers, the last in 1925 [Min. Abstr., vol. 3, p. 242]. He was elected an Honorary Member of our Society in 1905. (Obituary notices by L. Weber, *Actes Soc. Helvét. Sci. Nat.*, 1926, Sess. 107 (Fribourg), Biogr. pp. 1-15, with portrait and bibliography; *Schweiz. Min. Petr. Mitt.*, 1926, vol. 6, pp. 391-397, with portrait and bibliography of 137 items.)

BROOKS (Alfred Hulse) [1871-1924], for twenty years chief of the Alaska division of the United States Geological Survey, was born at Ann Arbor, Michigan, on July 18, 1871, and died at Washington, D.C., on November 22, 1924. He graduated at Harvard University and joined the United States Geological Survey in 1894, going to Alaska in 1898. He wrote numerous reports on the mineral resources of Alaska. A curious tin-bearing boron mineral from there was named hulsite after him. (Obituary by P. S. Smith, *Bull. Geol. Soc. Amer.*, 1926, vol. 37, pp. 15-48, with portrait and bibliography.)

CANFIELD (Frederick Alexander) [1849-1926], mining engineer and mineral collector, was born at Ferro Mont, near Dover, Morris Co., New Jersey, on April 7, 1849, and died in a private hospital after an operation on July 3, 1926. He graduated in 1870 at Rutgers College, New Jersey, and in 1873 at the School of Mines of Columbia College (afterwards University), New York City. As seen by the writer in 1924 he was living alone with his collection in a large and rather dilapidated house amid the relics of the old iron mines of Ferro Mont (or Ferromonte) in the New Jersey Highlands. There, working a magnetite ore in gneiss, was the famous Dickerson mine which was active from 1716 to 1891 and at one time leased by the firm E. Canfield & Co. ;

also the Canfield mine, worked in 1870-3; Canfield's phosphate mine in which the magnetite was full of apatite; and several others. Close by were also the mines of Mine Hill and Irondale, and the remains of many ancient forges and charcoal furnaces. Canfield saw the last of a dying industry, but he carefully preserved the fine mineral collection. This was contained in two large rooms, and had been started by his father, Frederick Canfield, who collected many fine specimens in the old days (1840-66) in the vicinity of Franklin Furnace and Sterling Hill, N.J. These old specimens were displayed in wall-cases, sealed up to prevent the access of dust, and left just as they had been arranged by his father in 1858 and 1864. Here were seen franklinite and gahnite as sharp octahedra measuring five inches along the edges. Besides the very complete and fine series of New Jersey minerals, the collection is a general one. Special mention may be made of some interesting specimens collected by Canfield in Bolivia in 1885-7; e.g. a large though rough crystal of argyrodite 6 inches across and weighing 14 lb. Some of this Bolivian material was submitted to S. L. Penfield, who in 1893 described canfieldite as a new cubic sulphogermanate of silver dimorphous with argyrodite. Later, however, argyrodite was proved to be cubic and not monoclinic; and when in 1894 Penfield discovered the isomorphous sulphostannate (also from Bolivia, though not in the Canfield collection), he transferred to this the name canfieldite. In 1889 Canfield published a brief 'Catalogue of the Minerals found in New Jersey', and in 1923 a useful list of private mineral collectors in America. He discovered the mineral mosesite and was one of the joint authors in the description of it. His valuable collection of about 9,000 specimens together with an endowment of \$50,000 he bequeathed to the United States National Museum at Washington, D.C., where the unique specimens may be seen by more than just a few favoured mineralogists (Obituary notice by C. Palache in *Amer. Min.*, 1927, vol. 12, pp. 67-70 with portrait and bibliography.)

DICK (Allan Brugh) [1833-1926], metallurgical chemist and designer of the 'Dick' microscope, was born at Edinburgh on May 31, 1833, and died at Hampstead, London, on June 12, 1926, at the advanced age of 93. Leaving the Edinburgh High School at an early age, he was apprenticed to Prof. George Wilson of Edinburgh, and in 1851 he became assistant to Dr. John Percy, who had just been appointed lecturer in metallurgy in the new 'Government School of Mines and of Science applied to the Arts' in Jermyn Street, London. In 1856 he took a post as chemist to

the firm of Walkers Parker & Co., lead and zinc smelters and refiners, at Bagillt in North Wales, and later spent three years in Spain investigating the lead and iron ores. In 1875 he returned to London, and since then he had always been in close touch with the Geological Survey and the Museum of Practical Geology. So long ago as 1853 he gave in the 'Philosophical Magazine' an analysis of the mineral hayesine (this analysis being quoted in Dana's fifth edition under ulexite). He made many chemical analyses of iron ores in connexion with the preparation of the Geological Survey Memoir on the Iron Ores of Great Britain, published in 1856, and it was then that he noticed the occurrence of anatase in the Cleveland ironstone, the crystals being measured by Prof. W. H. Miller. With Miller he also described in 1856 a crystallized bismuth alloy. Dick was the first to prepare metallic aluminium from the mineral cryolite, and a sample of this was exhibited by Faraday at the Royal Institution in 1855. Although not a member of our Society, Allan Dick communicated a few papers to the Magazine, notably on the optical properties of kaolin and on a new mineral geikielite (named after his old school-fellow and colleague, Sir Archibald Geikie), and in 1899 a brief description of the form of microscope which he had designed many years before. A fuller description of this ('Dick') microscope was given in a separate pamphlet issued in 1890, with a supplement in 1894. The distinctive feature of this convenient form of petrological and mineralogical microscope is that the stage is fixed while the polarizing and analysing nicols rotate together. With the aid of this instrument he did pioneer work in recognizing the presence of zircon and other heavy minerals in sands and clays. As recently as 1925 he showed that the shells of certain foraminifera from the Clyde estuary are composed mainly of minute needles of rutile. Since his death his interesting collection of minerals and microscope preparations has been presented by the family to the Museum of Practical Geology in London. (Obituary notice, with portrait, by H. H. Thomas, Trans. Geol. Soc. Edinburgh, 1927.)

DUBYANSKY (Viktor Viktorovich), Дубянский (Виктор Викторович) [1880–1925], was born on November 17, 1880, and died at Kiev on July 10, 1925. After studying at the University of Kiev he remained there as assistant in mineralogy to Prof. P. J. Armashevsky until 1909. He then went to Warsaw as curator of the mineral collection in the Polytechnic, becoming professor in 1915. Later he returned to Kiev as Professor of Mineralogy in the University and as a member of the

Ukranian section of the Russian Geological Survey; he was at one time also Dean and Rector of the University. His principal work was on the rocks of the extinct volcanoes of the Caucasian range. For that on Kazbek (Tiflis, 1904) he was awarded a medal, and the great monograph on Elbrus (Warsaw, 1914) gained for him the Akhmatov prize of the Academy of Sciences of Petrograd. (Obituary in Bull. Sect. Ukraine Comité Géol., 1925, pt. 6, pp. iii-vi, with portrait and bibliography.)

GEIKIE (*Sir* Archibald) [1835-1924], the celebrated geologist, was an original member of this Society, and served on its first Council in 1876-9 and again in 1885-8, but his only contribution to the Magazine was a playful set of verses (vol. 2, p. 271). He was born in Edinburgh on December 28, 1835, and after studying at Edinburgh University was appointed an assistant on the Geological Survey at the age of twenty, becoming Director for Scotland in 1867 and Director-General for the United Kingdom in 1882, from which position he retired in 1901. During part (1871-82) of that period he also acted as the first Professor of Geology and Mineralogy in the University of Edinburgh, being succeeded by his brother James Geikie. He was President of the British Association in 1892, of the Royal Society (1908-13), and of many other societies. Knighted in 1891, he was created K.C.B. in 1907, and received the rare Order of Merit in 1914. The mineral geikielite bears his name. He died at his home at Haslemere in Surrey on November 10, 1924. Of his numerous published works mention may be made here of his well-known 'Text-book of Geology' (1882; 4th edition, 1903), and his 'Ancient Volcanoes of Great Britain' (1897) which was based on his Presidential Addresses to the Geological Society in 1891 and 1892. His 'Autobiography' was published in 1924. See also 'Eminent living Geologists' in Geol. Mag., 1890, pp. 49-51, with portrait. (Obituary notices in Nature, 1924, vol. 114, pp. 758-760; Quart. Journ. Geol. Soc., 1925, vol. 81, pp. lii-lxii; Proc. Roy. Soc. London, Ser. A, 1926, vol. 111, pp. xxiv-xxxix, with portrait.)

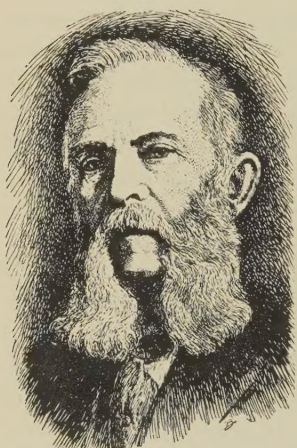
HARRISON (*Sir* John Burchmore) [1856-1926], distinguished for his services in tropical agriculture, was born at Birmingham on May 29, 1856, and died at Georgetown, British Guiana, on February 8, 1926, just as he was on the point of returning home after over forty-six years' service in the West Indian colonies. A scholar of Christ's College, Cambridge, he took his degree in 1877, and in 1879 he was appointed Professor of Chemistry and Agricultural Science in Barbados. In 1889

he became Government Analyst and Professor of Chemistry in British Guiana, the post of Director of the Department of Science and Agriculture being added in 1904. Although his main work was on agricultural chemistry and tropical products, he also did much geological work, and in 1899 was awarded the Wollaston Fund of the Geological Society of London. With A. J. Jukes-Browne he prepared a geological map with explanation (1890) of Barbados and wrote on coral rocks and oceanic deposits. He also prepared a geological map of British Guiana and published in 1908 an excellent book on the 'Geology of the goldfields of British Guiana' in which there are many chemical analyses and petrographical descriptions of rocks, and an early account of the occurrence of diamond. His geological work led to the discovery of important deposits of bauxite in British Guiana. In 1925, after much chemical work, he announced the discovery of a palladium amalgam or palladium mercuride from the diamond-bearing gravels of the Potaro river in British Guiana [Min. Abstr., vol. 3, p. 4]. This new mineral he modestly declined to have named after himself, and he suggested the name potarite, a name which has since appeared in print, though his own account of it was never published. His valuable collection of over 2,000 micro-sections of rocks, mainly from British Guiana, was bequeathed to the Sedgwick Museum at Cambridge. In recognition of his work in the colonies he was created C.M.G. in 1901 and knighted in 1921.

HILLEBRAND (William Francis) [1853-1925], celebrated as a mineral chemist, was born on December 12, 1853, at Honolulu, where his father was a physician,¹ and died on February 7, 1925, at Washington, D.C. After two years at Cornell University he went in 1872 to Heidelberg, where he studied chemistry under Bunsen and Kirchhoff. Working there with T. H. Norton they prepared metallic cerium, lanthanum, and didymium for the first time, and Hillebrand discovered the pyrophoric property of cerium filings, which now has an extensive practical application. In 1876-7 he worked at Strassburg under Fittig, and in 1877-8 at the Mining Academy at Freiberg. Returning to America he worked for a time as an assayer in Leadville, Colorado, and joining the United States Geological Survey as chemist he worked in the laboratory at Denver from 1880 to 1885. After being transferred to head-quarters in Washington he remained with the Survey until 1908, when he became chief chemist of the Bureau of Standards in Washington. In connexion

¹ William Hillebrand (1821-86) whose book 'Flora of the Hawaiian Islands' (1888) was annotated and published after the author's death by W. F. Hillebrand.

with his work on the Survey many new and interesting minerals came to him for analysis, and these were described in a long series of papers often in collaboration with other authors. Under his own name he described as new minerals antlerite, bravoite, emmonsite, guitermanite, and zunyite, and eleven others were described in joint papers. In 1888-92 he made a number of very detailed analyses of uraninite



W. F. HILLEBRAND.

(pitchblende) in which he found a gas. This gas evidently puzzled him, and he concluded that it was mainly nitrogen. Sir William Ramsay afterwards, in 1895, identified it as helium, and uraninite was the first known terrestrial source of this element. The careful and detailed analytical work for which Hillebrand was noted led to the recognition in rocks of several chemical elements not previously suspected to be present. His well-known book 'Analysis of silicate and carbonate rocks' was first issued in 1907 as a Bulletin of the United States Geological Survey, and passed through three editions, besides being translated into German. It was preceded by his 'Principles and methods

of rock analyses' (1900) and, with F. W. Clarke, by 'Analyses of rocks with a chapter on analytical methods' (1897). He did not altogether cease his work on minerals after he left the Geological Survey in 1908, and for many years he continued his investigation of the carnotite minerals, the results of which were published in 1924. In 1906 he was president of the American Chemical Society, and for many years an associate editor of its journal. The mineral hillebrandite was named after him in 1908. (Obituary notices by C. E. Waters, *Science*, New York, 1925, vol. 61, pp. 251-253; and F. W. Clarke, *Mem. National Acad. Sci. U.S.A.*, 1927, vol. 21.)

HOLDEN (Edward Fuller) [1901-25] was born on August 28, 1901, at Woonsocket, Rhode Island, where his father was principal of the High School, and was drowned whilst bathing on the coast of Maine on August 5, 1925. Although he had not quite reached the age of 24 he had accomplished an enormous amount of work and had a promising career before him. He left a widow and three small sons. After

studying mining engineering at the Pennsylvania State College (B.Sc. 1921), he became in 1921 instructor in mineralogy under Prof. E. H. Kraus in the University of Michigan at Ann Arbor, taking there the degrees of M.Sc. (1923) and Ph.D. (1925). Since 1917 he had contributed sixteen papers to the 'American Mineralogist', of which journal he was an associate editor since 1923, and had written over 1,200 abstracts for that journal and for 'Chemical Abstracts'. He was joint author with Prof. E. H. Kraus of an excellent text-book on 'Gems and gem minerals', which appeared shortly after his death. Special mention may be made of his intensive study into the nature of the colouring matter of different varieties of quartz. A series of unfortunate errors in his circumstantial description of a supposed new mineral 'ceruleo-fibrite', although gracefully acknowledged by himself, is rather difficult to overlook [Min. Abstr., vol. 2, pp. 10, 344]. (Obituary notices by E. H. Kraus, *Science*, New York, 1926, vol. 63, pp. 84-85; *Amer. Min.*, 1926, vol. 11, pp. 57-59, with portrait and bibliography.)

HOVEY (Edmund Otis) [1862-1924], Curator of Geology in the American Museum of Natural History, New York City, was born at New Haven, Connecticut, on September 15, 1862, and died suddenly, being struck by paralysis in his office, on September 27, 1924. His father, the Rev. Horace Carter Hovey, an amateur geologist, wrote on caves. After graduating at Yale University he became a school teacher, but returning to Yale in 1886 as a graduate student he worked under J. D. Dana and was assistant in the Mineralogical Laboratory under S. L. Penfield. In 1890-1 he studied petrology under H. Rosenbusch at Heidelberg, and visited Vesuvius. The results he obtained as superintendent of the mineral exhibit of the State of Missouri for the Columbian Exposition in Chicago in 1893 led to the offer of a post in the American Museum of Natural History. There he set up some very striking models illustrating geological structures and types of scenery. The volcanic eruptions of Mt. Pelé in Martinique were studied on the spot in 1902 and 1903, and he took part in an expedition to Greenland in 1915. He gave his services to many organizations and was secretary of the Geological Society of America. In addition to geological papers he was the author of several papers on meteorites, one of which was published posthumously. (Obituary notices by H. P. Whitlock, *Amer. Min.*, 1925, vol. 10, pp. 58-60, with portrait; C. P. Berkey, *Mining and Metallurgy*, 1925, vol. 6, p. 41; J. F. Kemp, *Bull. Geol. Soc. Amer.*, 1925, vol. 36, pp. 85-100, with portrait and bibliography.)

KATZER (Friedrich=Bedřich) [1861-1925], since 1898 Director of the Geological Survey of Bosnia and Herzegovina, was born at Rokycany (= Rokitzan) in Bohemia on June 5, 1861, and died at Sarajevo on February 3, 1925. He studied at Prague, and in 1883-8 was assistant in mineralogy and geology in the Bohemian Technical High School at Prague, in 1888-91 superintendent of the station for testing building materials at Vršovice (= Wrschowitz) near Prague, and in 1892-5 assistant in mineralogy, geology, and ore-deposits in the Mining Academy at Leoben in Styria. From 1895 to 1898 he was in Brazil as geologist of the State of Pará and in charge of a section of the Museu Paraense. His first work in 1886 was a German edition of J. Krejčí's text-book on mathematical crystallography. He wrote several papers on Bohemian minerals, in one of which he described hoeferite as a new species, and a large volume (1606 pp.) 'Geologie von Böhmen' (1889-92; 2nd edit., 1902). In a paper on iron and manganese ores from Bosnia he described the new mineral pocchite. His 'Geologie Bosniens und der Hercegovina' (1924-5) was not completed; a part issued posthumously contains a portrait of the author [Min. Abstr., vol. 3, p. 278].

KEMP (James Furman) [1859-1926], since 1891 Professor of Geology in Columbia University, New York City, was born in New York City on August 14, 1859, and died suddenly from heart failure when leaving home for the university on November 17, 1926. He graduated from Amherst College in 1881 and the Columbia School of Mines in 1884, and after further study of mineralogy and petrology in Munich and Leipzig he acted as instructor and assistant professor of geology at Cornell University from 1886 to 1891. Extremely genial and cordial, he was very popular with his students (amongst whom he was affectionately known as 'Uncle Jimmy') and a wide circle of friends. At one time he was a member of the Geological Survey of the United States and also that of the State of New York. In addition to geo-



J. F. KEMP.

logical work he was widely known for his work on ore-deposits. His book 'The ore deposits of the United States (and Canada)' (1893; 5th

edit., 1903) was the first systematic treatise on economic geology in America. Another successful book was his 'Handbook of rocks for use without the microscope' (1896; 5th edit., 1911). He also wrote the article 'Mineral Deposits' in the eleventh edition of the 'Encyclopaedia Britannica' (1911). He was a past-president of the Geological Society of America, the American Institute of Mining Engineers, and several other bodies. The mineral kempite [Min. Abstr., vol. 2, p. 338] bears his name. (Obituary notices by C. Schuchert in Amer. Journ. Sci., 1927, ser. 5, vol. 13, pp. 99-100; R. Peele and C. P. Berkey in Engin. and Mining Journ., 1926, vol. 122, pp. 872-873, with portrait; W. Lindgren in Econ. Geol., 1927, vol. 22, pp. 84-90.)

KRANTZ (Friedrich Ludwig Robert) [1859-1926], the well-known mineral dealer at Bonn, was born at Glogau in Silesia on October 1, 1859, and died on March 12, 1926. He studied chemistry and pharmacology at Freiburg in Baden and took the degree of Ph.D. at Erlangen in 1888 with a dissertation on the crystallography of some organic compounds (Zeits. Kryst. Min., vol. 14, pp. 456-478), this work having been done under Prof. C. Hintze at Breslau. He was a nephew of Dr. August Krantz (1809-72), who founded the firm of Krantz in Berlin in 1833, removing to Bonn in 1850. The firm has supplied specimens, apparatus, and models for the study and teaching of mineralogy and geology to museums, universities, and colleges all the world over. Numerous fine mineral specimens have been supplied for the British Museum collection ever since 1838, and in 1859 a special crystal collection numbering 2,624 specimens was acquired. After the death of Dr. A. Krantz in 1872 the business was carried on by his son-in-law Theodor Hoffmann, and during that period Carl Hintze, afterwards professor at Breslau, was for a time in the employ of the firm. Dr. F. Krantz joined after taking his degree in 1888, and since 1891 the business has been carried on under his name. Combining business ability with scientific knowledge he considerably extended the business, and removing to new quarters in Bonn some fine buildings were erected. Detailed catalogues of special



F. KRANTZ (in 1923).

collections prepared in collaboration with well-known experts were issued, and collectors were maintained in various countries. In addition to the crystallographic work mentioned above, Dr. F. Krantz wrote on thorium minerals in connexion with incandescent gas-lighting (1896) and on the development of the Upper Silesian zinc industry (1911). He was elected a member of our Society in 1907. Mrs. Krantz helped in the business during the difficult period of the war, and with this experience she has been able to carry on since the death of her husband—again with the help of a nephew.

KREJČÍ (August) [1856–1925] was born at Písek in Bohemia on January 14, 1856, and died there on August 21, 1925. For over forty years he had actively collected and studied the minerals of the district around his native town. From the well-known pegmatites he collected the beryllium minerals described by K. Vřba. In one of his recent papers [Min. Abstr., vol. 2, pp. 335, 354; vol. 3, p. 123] he described písékite as a new mineral, and in a paper published posthumously is given a general account of this interesting district with a summary list of the minerals found there.

KUPFFER (August Ernestovich), Купфферъ (Августъ Эрнестовичъ) [1842–1918] was born at Goldingen in Courland on May 1 (old style, April 18), 1842, and died in Petrograd on August 10 (July 28), 1918. After studying at Goldingen and Dorpat, he was assistant in chemistry in the University of Dorpat (1868), under F. K. Beilstein in the Technological Institute at Petrograd (1872), and in the Agricultural Academy at Petrovsko-Razumovskoe near Moscow (1873). At the last-named institution he was later (1895) also assistant in mineralogy and geology, and he went with E. S. Fedorov in 1905 to the Institute of Mines at Petrograd. There he published a catalogue of the collection of minerals in the Institute of Mines (1911, 575 pp.) and assisted Fedorov in the construction of instruments and models. Many of his chemical analyses were published in the works of Fedorov and other authors. Under his own name he gave in 1870 a paper on the chemical composition of the Baltic Silurian strata, and in 1911 he described the meteorites of Augustinovka, Petropavlovsk, and Tubil. In 1871 he read before the Russian Mineralogical Society a preliminary paper on igneous and contact rocks of Olonetz, on which he continued to work for ten years, forming a large collection of specimens and making over 300 chemical analyses and many micro-sections. The collections and the nearly

completed manuscript of this work were destroyed by fire at Petrovsko-Razumovskoe in 1880.

LEHMANN (Johannes Georg) [1851–1925]. The name of J. Lehmann was familiar in the eighties of last century in connexion with discussions on the origin of the crystalline schists. Since then he had dropped out of scientific circles and became almost forgotten, especially as he had assumed the name Lehmann-Hohenberg. He was born at Königsberg in East Prussia on April 11, 1851, and died at Weimar on April 12, 1925. He graduated at Bonn under G. vom Rath in 1874 with a dissertation on the rock and mineral inclusions in the Lower Rhenish basalts, and it was in one of these inclusions that he discovered the mineral ettringite. The same year he was appointed a geologist on the Geological Survey of Saxony, when he did good work on the granulite rocks. Returning to Bonn in 1879 he became museum assistant to G. vom Rath, where he wrote his book on the crystalline schists (1883–4), and in 1886 he succeeded H. Laspeyres as Professor of Mineralogy and Geology in the University of Kiel. There, being possessed of private means (through his wife), he gave the land for the new institute building and spent much on installing the collections; but he had the misfortune to see this destroyed by fire in 1892. He retired in 1903 and devoted the rest of his life to religious and social questions. His last mineralogical work in 1885–6 dealt with the origin of the microcline and perthite structures in feldspars, and at the Geological Congress in London in 1888 he took part in the discussion on crystalline schists. (Obituary by K. Spangenberg, *Centralblatt Min., Abt. A*, 1926, pp. 192–199, with bibliography.)

LEWIS (William James) [1847–1926], for forty-five years Professor of Mineralogy in the University of Cambridge, was born, the second son of the Rev. John Lewis, at Llanwyddelan in Montgomeryshire on January 16, 1847, and died at the home of his sister, Mrs. G. T. Pilcher, at Godalming, Surrey, on April 16, 1926. From Llanrwst Grammar School he gained a scholarship in 1865 to Jesus College, Oxford, and after taking first classes in both mathematics and natural science he was elected a Fellow of Oriel College in 1869, and gained the Senior Mathematical Scholarship in 1871. Being unmarried he held this fellowship until his death. After acting as an assistant master at Cheltenham College in 1871–2, he studied mineralogy under Professor W. H. Miller at Cambridge and Professor G. vom Rath at Bonn. In 1875 he was appointed an assistant in the Mineral Department of the British

Museum, then under the keepership of Professor N. Story-Maskelyne in the old building at Bloomsbury. Owing to lung trouble he resigned from the position in 1877, being succeeded by L. Fletcher, and he was ordered abroad by the physician.¹ In 1879 during the illness of W. H. Miller he acted as deputy, and in 1881 was appointed Professor of Mineralogy in succession to Miller, who had been professor since 1832. He took the Cambridge M.A. degree by incorporation in 1880, and



W. J. LEWIS (in 1898).

since then had lived in rooms at Trinity College. During Lewis's tenure of office the department was much increased in efficiency and especially in the number of students. The material in the Mineralogical Museum was catalogued and considerably added to, notably by the acquisition of the Carne and Wiltshire collections, and by specimens obtained by the professor himself during his many collecting trips to the Binnenthal and other mineral localities in Switzerland. In 1919, at the age of seventy-two years, when alone in the Lengenbach quarry, he had the misfortune to break his leg. There he lay in the snow all night, and in the morning he found a piece of wood to bind as a splint, thus

enabling him to crawl out and fortunately attract attention.

Lewis acted as secretary of the Crystallogological Society from its foundation in 1876 until its amalgamation with the Mineralogical Society in 1883, and was librarian of our Society from 1889 to 1925 and president in 1909-12. He joined the Chemical Society in 1869, the Royal Astronomical Society in 1873, and was elected a Fellow of the Royal Society in 1909. In Cambridge he was director of the University Scholastic Agency, which he founded as a private venture in 1884, and combined with it an insurance scheme. To his credit, he made no great burden for the bibliographer. In the preparation of his excellent textbook on geometrical crystallography, published in 1899, he devoted much

¹ His observations on the polarization of the corona were not made during that period, but during the eclipse expedition to Spain in 1870 and to Ceylon in 1871. These are recorded in *Mem. Roy. Astronomical Soc.*, 1879, vol. 41, pp. 301, 325. (Curiously, the same volume records the observations made by another William J. Lewis during the eclipse of 1860.) Another slip in previous obituary notices is the date of the Oriel Fellowship.

time and infinite pains. He delighted in the intricacies and difficulties presented by twinned crystals, and in devising geometrical methods for dealing with the rhombohedral system of crystals. Indeed, his students were often rather relieved when they met a mineral that was not rhombohedral and 'had no twins'. The rare mineral lewisite from Brazil bears his name. (Obituary notices in *Nature*, London, 1926, vol. 117, pp. 628-629; *Proc. Roy. Soc. London*, Ser. A, 1926, vol. 111, pp. xlv-xlviii, with portrait; *Journ. Chem. Soc.*, 1926, pp. 3245-3246.)

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- (2) Notes on the crystallography of leucaurin. *Journ. Chem. Soc.*, 1875, vol. 13, pp. 1147-1148.
- (3) Notice of crystallographic forms of glaucodote. *Phil. Mag.*, 1877, ser. 5, vol. 3, pp. 354-356, pl. I; *Proc. Cryst. Soc.*, 1877, pt. 1, pp. 31-34, pl. II.
- (4) Crystallographic notes. [Barium nitrate, sphene, gold.] *Phil. Mag.*, 1877, ser. 5, vol. 3, pp. 453-456, pl. IV; *Proc. Cryst. Soc.*, 1877, pt. 1, pp. 37-40, pl. III; *Zeits. Kryst. Min.*, 1878, vol. 2, pp. 64-67, pl. IV.
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- (6) Note on the analysis of the rhombohedral system. *Phil. Mag.*, 1879, ser. 5, vol. 7, pp. 176-178; *Proc. Cryst. Soc.*, 1882, pt. 2, pp. 64-66; *Zeits. Kryst. Min.*, 1879, vol. 3, pp. 426-428.
- (7) Crystallographic notes. [Pseudobrookite, ludlamite, idocrase, zoisite, quartz.] *Phil. Mag.*, 1882, ser. 5, vol. 14, pp. 119-123, pl. III; *Proc. Cryst. Soc.*, 1882, pt. 2, pp. 108-113, pl. VII; *Zeits. Kryst. Min.*, 1883, vol. 7, pp. 181-186.
- (8) On the measurements of a bead of platinum, by the late Professor W. H. Miller. *Proc. Cambridge Phil. Soc.*, 1882, vol. 4, pp. 236-239.
- (9) On a crystal of stephanite from Wheal Newton. Expression for the error due to eccentricity. *Proc. Cambridge Phil. Soc.*, 1882, vol. 4, pp. 240-245; *Zeits. Kryst. Min.*, 1883, vol. 7, pp. 575-580.
- (10) On the crystallography of miargyrite. *Proc. Cambridge Phil. Soc.*, 1883, vol. 4, pp. 365-384, pl. X; *Zeits. Kryst. Min.*, 1884, vol. 8, pp. 545-567.
- (11) On idocrase and other minerals recently found near Zernatt. *Min. Mag.*, 1886, vol. 7, p. 9.
- (12) Obituary notice of Gerhard vom Rath. *Min. Mag.*, 1888, vol. 8, pp. 121-123.
- (13) [Crystallographic determinations]: in W. J. Sell, On [a series of salts of a base containing chromium and urea. *Proc. Roy. Soc. London*, 1889, vol. 45, pp. 321-345.
- (14) Note on a crystal of tourmaline. *Min. Mag.*, 1893, vol. 10, p. 142.
- (15) On the humite series. *Min. Mag.*, 1896, vol. 11, pp. 137-140.
- (16) A treatise on crystallography. Cambridge, 1899, xii + 612 pp., 553 figs.
- (17) [Crystallography of bromomethylfurfuraldehyde.] *Journ. Chem. Soc.*, 1899, vol. 75, p. 426.

(18) On some remarkable composite crystals of copper pyrites from Cornwall. (With A. L. Hall.) *Min. Mag.*, 1900, vol. 12, pp. 324-332; *Zeits. Kryst. Min.*, 1901, vol. 34, pp. 321-329.

(19) On Grassmann's method of axial representation, and its application to the solution of certain crystallographic problems. *Min. Mag.*, 1900, vol. 12, pp. 333-342; *Zeits. Kryst. Min.*, 1901, vol. 34, pp. 330-338.

(20) Notes on minerals from the neighbourhood of Binn (Switzerland)—mispickel, pyrites, diopside, and quartz. *Min. Mag.*, 1903, vol. 13, pp. 291-293.

(21) On some twins of calcite; and on a simple method of drawing crystals of calcite and other rhombohedral crystals, and of deducing the relations of their symbols. *Min. Mag.*, 1908, vol. 15, pp. 62-77.

(22) [Crystallography of platinocyanides.] *Journ. Chem. Soc.*, 1908, vol. 113, pp. 1451, 1455.

(23) Wiltshireite: a new mineral. *Nature*, 1910, vol. 84, p. 203; *Phil. Mag.*, 1910, ser. 6, vol. 20, pp. 474-475; *Zeits. Kryst. Min.*, 1910, vol. 48, pp. 514-515.

(24) On rathite and its variety, wiltshireite. *Min. Mag.*, 1912, vol. 16, pp. 197-206.

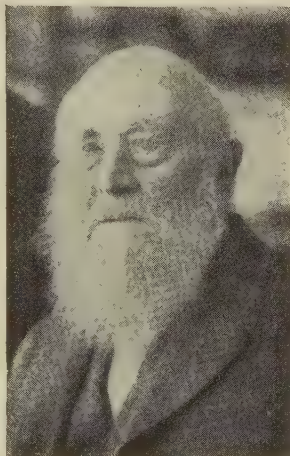
(25) Notes on the history of the parish of North Wraxhall, Co. Wilts. With a life of the late rector Francis Harrison. London, 1913, vii + 197 pp., 3 pls.

(26) Ilmenite from the dolomite at Binn, Switzerland. *Min. Mag.*, 1913, vol. 16, pp. 343-344.

(27) On crystals of albite from Alp Rischuna, and pericline twins from La Fibbia, Switzerland. *Min. Mag.*, 1915, vol. 17, pp. 178-188, pl. VII.

LIVEING (George Downing) [1827-1924], for forty-seven years Professor of Chemistry at Cambridge, was for several years (1898-1908) a Vice-President of our Society. He was one of the members of the select Crystallogological Society, which was amalgamated with the Mineralogical Society in 1883. Born on December 21, 1827, the eldest son of Edward Liveing, of Nayland in Suffolk, he entered St. John's College in 1847, taking his degree in 1850 as eleventh Wrangler, and in 1851 he headed the first list of the new Natural Sciences Tripos with distinction in chemistry and mineralogy. After studying for a short time under C. F. Rammelsberg in Berlin, he returned to Cambridge as Fellow and Lecturer in St. John's College, where he started a chemical laboratory. In 1861, after having acted as deputy, he was appointed Professor of Chemistry, and he gradually built up the fine school of chemistry and the extensive chemical laboratories of the University. He retired from that post in 1908, being succeeded by Sir William J. Pope, another member of our Society. His more important original work related to spectroscopy, on which a long series of papers in collaboration with Sir James Dewar appeared in the Proceedings of the Royal Society since 1878. A series of three remarkable and now almost forgotten papers 'On solution and crystallization' was published in the Transactions of the Cambridge Philosophical Society (1889-91), in which, unaware of the previous work

of Bravais and Sohncke, he developed a theory of crystal-structure, and calculated the relative molecular condensation (or reticular density) in different planes and the relative distances between these planes for a large number of minerals. He also wrote on rocks from the Channel Islands, giving geological maps, and designed a universal goniometer. He died on December 26, 1924, at the advanced age of 97; he had been knocked down by a bicycle in the narrow streets of Cambridge and he never recovered from that accident. The accompanying photograph was taken in the University Chemical Laboratory by Mr. F. J. Stoakley, shortly before the Professor's death. A mineral from the Binnenthal in Switzerland was named liveingite after him in 1901. (Obituary notices have appeared in *Nature*, 1925, vol. 115, pp. 127-129; *Journ. Chem. Soc. London*, 1925, vol. 127, pp. 2982-2984, with portrait; *Proc. Roy. Soc. London*, Ser. A, 1925, vol. 109, pp. xxviii-xxix, with portrait.)



G. D. LIVEING
(at the age of 97).

MARTIN (Daniel Strobel) [1842-1925], of Brooklyn, New York, continued to add to the collections of his father, Benjamin N. Martin (d. 1883), which were afterwards divided between the Charleston Museum in South Carolina and the Brooklyn Museum. He was formerly Professor of Geology in the Rutgers Female College at New York and in the College for Women at Columbia, South Carolina. He was one of the founders of the New York Mineralogical Club, the first meeting being held in his home in 1886. He was responsible for the mineral names schernikite and winchellite.

MEUNIER (Étienne Stanislas) [1843-1925], Professor of Geology in the Natural History Museum at Paris, was born in Paris on July 18, 1843, and died on April 23, 1925. After acting as 'préparateur' in chemistry at the Polytechnic School, he entered the Museum in 1867 as assistant in geology, also acting for a time from 1880 as Professor of Natural History in the École normale supérieure d'Institutrices and from 1889 as Professor of Geology in the National School of Agriculture at

Grignon (Seine-et-Oise). In 1892 he became head of the department in the Museum with the title of Professor of Geology, retiring in 1920 with the title of Honorary Professor. He was a voluminous writer, being responsible for 298 titles up to the year 1900 in the Royal Society's Catalogue of Scientific Papers, 53 titles in the Mineralogy volumes [those in the Geology volumes not counted] of the International Catalogue of Scientific Literature (1901-14), 27 entries up to the year 1910 in the British Museum (Natural History) Catalogue of Books, and only 3 in 'Mineralogical Abstracts' since 1915. He was also the editor of various popular magazines. Several of his books were based on his public lectures at the Museum, where he had charge of the collection of meteorites. Meteorites specially interested him ever since 1867, and in his '*Géologie comparée*' he compared these in detail with terrestrial rocks, speculating also as to the composition of the interior of the earth and of the heavenly bodies (*Le ciel géologique*). His chemical work on the artificial production of minerals was extended to meteoric minerals and meteorites, and this information is collected in his books '*Les méthodes de synthèse en minéralogie*' (1891) and '*La géologie expérimentale*' (1899), and in P. N. Chirvinsky's book '*Reproduction artificielle de minéraux au XIX^e siècle*' (Kiev, 1903-6; with portrait of Stanislas Meunier on p. 308).

MILLER (Willet Green) [1866-1925], since 1902 Provincial Geologist of Ontario, was born in Norfolk Co. on Lake Erie, Ontario, on July 19, 1866, and died of meningitis at Toronto on February 4, 1925. He studied at the University of Toronto under E. J. Chapman, and after graduating in 1890 was teaching Fellow in Mineralogy and Geology with work on the Geological Survey of Canada during the summer months. In 1893 he went to the School of Mining at Kingston, Ontario, and was afterwards Professor of Geology in Queen's University. During that period he attended short post-graduate courses at Chicago, Harvard, and Heidelberg, and in 1897-1901 did field-work for the Ontario Bureau of Mines (now Department of Mines). As Provincial Geologist his work soon led to economic results, and he was very closely connected with the remarkable development of northern Ontario. He recognized in 1903 the occurrence of cobalt and nickel arsenides and native silver at Cobalt, this place so named by him being now the site of an important mining town and centre. His well-illustrated book, '*Minerals and how they occur*' (1906), and his several reports and guide-books on different districts have been of the greatest use to prospectors, and he contributed largely to the valuable report issued in 1917 by the Royal Ontario Nickel

Commission. The important mineral deposits of Ontario being all in rocks of pre-Cambrian age, Miller made a special study of these rocks and their correlation. On this he was a leading authority, and it formed the subject of a series of interesting lectures which he gave in 1924 at the Royal School of Mines in London. He had been selected as president of the Geological section of the British Association meeting in 1925, but death intervened. (Obituary notices by C. W. Knight, *Trans. Canadian Inst. Mining Metall.*, 1925, vol. 28, pp. 19-47, with several portraits; J. B. Tyrrell, *Bull. Geol. Soc. Amer.*, 1926, vol. 37, pp. 99-110, with portrait and bibliography.)

MURGOCI (George) [1872-1925], a member of this Society since 1920, was born at Braila in Rumania on July 20, 1872, and studied physics, chemistry, and mathematics at the University of Bucharest, taking his degree in 1895. In his school-days he went by the name of Munteanu (meaning from the mountains) and later he adopted the compound name Munteanu-Murgoci, which appears in the titles of some of his earlier published papers. In 1896 he was appointed demonstrator in mineralogy and petrology in the University. Later he studied at the Universities of Vienna, Munich, and Paris. At Munich he obtained the doctorate in 1900 with a dissertation 'Über die Einschlüsse von Granat-Vesuvianfels in dem Serpentin des Paríngu-Massiv's (Rumänien)', in which he described lotrite as a new mineral. There he met an English lady, Agnes Kelly (the result of whose work on conchite, carried out in Munich, was published in vol. 12 of this Magazine), whom he married in 1904. He then travelled in America, and when in California he described a soda-amphibole under the name laneite. His work on the blue soda-amphiboles was never completed, his last contribution on this subject being in 1922. Another subject to which he had devoted much study, but unfortunately never completed, was that of Rumanian amber, a general review of which he published in 1903. One of the several varieties of Rumanian amber that have been distinguished has been named, after him, 'muntenite', but no description of this seems



G. MURGOCI (in 1925).

to be available. In 1906 he was appointed Geologist in the Geological Institute (Survey) of Rumania and Chief of the Agrogeological Section, and in 1908 Professor of Mineralogy and Geology in the Polytechnic High School at Bucharest. His later work dealt mainly with the geology and soils of Rumania and especially with the tectonics of the Southern Carpathians. He took a leading part in Agrogeological Congresses, being President of the section on the classification and nomenclature of soils at Rome in 1924. During the war he was in Bessarabia studying ethnological problems in relation to Rumanian unity. In 1919 he was called to Cluj (= Kolozsvár) to help in the reorganization of the University and to take charge of the courses of mineralogy and petrology. His *Geography of Rumania* is a standard book in secondary schools in Rumania and has passed through several editions; and he also wrote class-books on geology and mineralogy. At the time of his death on March 5, 1925, he was preparing an agrogeological map of Europe.

PECK (Frederick Burritt) [1860-1925], since 1897 Professor of Geology and Mineralogy in Lafayette College at Easton, Pennsylvania, was born at Seneca Castle, New York, on August 19, 1860, and died at Easton, Pa., on November 2, 1925. After graduating from Amherst College, Massachusetts, he taught in a school in Colorado, returning to Amherst in 1891 as assistant professor of Geology. In 1895-6 he studied in Munich under Groth, taking the Ph.D. degree with a dissertation on the crystallography of bournonite and the thermal conductivity of stibnite and bournonite (*Zeits. Kryst. Min.*, 1896, vol. 27, pp. 299-320). For a time (1898-1909) he was an assistant on the United States Geological Survey. He wrote on the talc deposits of Easton and on other economic minerals in Pennsylvania. (Obituary notices by A. H. Fretz in *Amer. Min.*, 1926, vol. 11, pp. 55-56; and by H. W. Shimer in *Bull. Geol. Soc. Amer.*, 1926, vol. 37, pp. 111-114, with portrait and bibliography.)

PONI (Petru) [1841-1925], Rumanian chemist and statesman, was born at Sesărești in the district of Jassy on January 4, 1841. He studied chemistry at the Lyceum at Jassy and in Paris under H. Sainte-Claire Deville and M. Berthelot. In 1866 he was appointed Professor of Physics and Chemistry in the Lyceum, afterwards the University, of Jassy, retiring in 1911. He was Minister of Education and President of the Agrarian Council in Rumania, and several times President of the Rumanian Academy. In the first volume of *Ann. Sci. Univ. Jassy*, a journal which he founded in 1900, there appeared in French his

systematic account of Rumanian minerals (136 pp.), and a Rumanian edition appeared the same year in *Anal. Acad. Română* [see *Min. Abstr.*, vol. 3, p. 278]. There he described badenite and brostenite as new minerals. He made an exhaustive chemical study of Rumanian petroleum and ozocerite, and also of salt deposits and waters in the hope of finding workable potash deposits in his native country. His text-books on physics and chemistry, written in Rumanian, were extensively used and passed through many editions. A mineral has been named ponite in his honour. He died on April 2, 1925. (Obituary notices by G. G. Longinescu in *Bull. Sect. Sci. Acad. Roumaine*, 1925, vol. 9, pp. 169-172; and by I. Borcea in *Ann. Sci. Univ. Jassy*, 1926, vol. 14, pp. 1-7, with portrait and bibliography.)

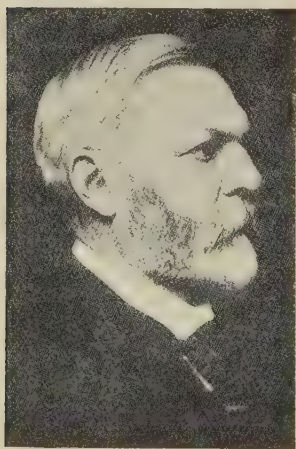
POSTLETHWAITE (John) [1840-1925], an amateur geologist, spent his life in the service of the Cockermouth, Keswick, and Penrith Railway Company, first as booking-clerk and afterwards as accountant. In his spare time he contrived to find out much about the minerals and rocks of the district in which he happened to be located. His useful book, 'Mines and Mining in the Lake District' (1877; 3rd edition, 1913), was based on a paper read by him in 1874 before the Keswick Literary and Scientific Society. He was honorary curator of the Museum of that Society. Elected a Fellow of the Geological Society of London in 1882, he contributed a few papers on Cumberland geology to the *Quarterly Journal*, and was awarded the Lyell Fund in 1914. After his retirement from the Railway Company he left his house, 'Chalcedony Villa', at Keswick, and went to Workington, where he died on September 20, 1925, at the age of 85.

PUFAHL (Otto Hermann August) [1855-1924], since 1897 Professor of Metallurgy and Assaying in the Mining Division of the Technical High School of Charlottenburg, Berlin, was born at Regenwalde in Pomerania on April 26, 1855, and died after a long illness on November 18, 1924. In 1876 he was appointed a chemist on the Geological Survey (*Landesanstalt und Bergakademie*) of Prussia, when he made some mineral analyses, e. g. of amalgam from Friedrichslegen in 1882, recorded in *Dana*. In 1920 and 1922 he gave chemical analyses of minerals from Tsumeb, South-West Africa, describing duftite and germanite as new species. In germanite he found 6.20 % of the rare element germanium. The Bolivian mineral pufahlite, named

after him, is a zinciferous variety of teallite. (Obituary in *Metall und Erz*, Halle a. S., 1925, vol. 22, pp. 72-74, with portrait.)

PUMPELLEY (Raphael) [1837-1923], American geologist and explorer, was born at Oswego, New York, on September 8, 1837, and died at Newport, Rhode Island, on August 10, 1923. He studied at the Mining Academy of Freiberg, Saxony, from 1856 to 1860, and in 1861-4 was employed by the Japanese and Chinese governments on economic work. In 1865 he was Professor of Mining Engineering at Harvard University, and later State Geologist of Michigan and of Missouri, and on the United States Geological Survey. Explorations in Turkestan were undertaken in 1903-4. He made a special study of the mineral paragenesis of the copper deposits of Michigan, and recently (1925) a mineral from there has been named pumpellyite [*Min. Abstr.*, vol. 3, p. 8]. (Obituary notice by B. Willis, *Bull. Geol. Soc. Amer.*, 1925, vol. 36, pp. 45-84, with portrait and bibliography; *Amer. Journ. Sci.*, 1923, ser. 5, vol. 6, pp. 375-376.)

ROEBLING (Washington Augustus) [1837-1926], a well-known private collector of minerals, was the son of John Augustus Roebling (1806-1869),



W. A. ROEBLING.

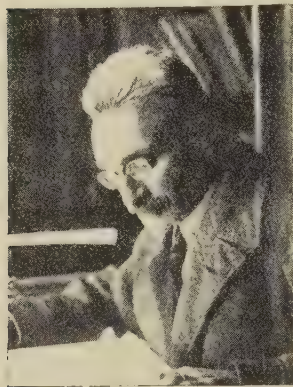
who was born at Muhlhausen in Prussia and migrated to the United States in 1831, where he was famous as a builder of suspension bridges. Wire-ropes for this purpose were manufactured by the firm of John A. Roebling & Sons, which settled near Trenton, New Jersey, the town being now known as Roebling. Colonel Washington A. Roebling was born at Saxonburg in Pennsylvania on May 26, 1837, and after an engineering education at the Rensselaer Polytechnic Institute at Troy, N.Y., he entered his father's business. After his father's death he carried on the building of the Brooklyn bridge, which when completed in 1883 was the largest suspension bridge in the world. Colonel

Roebling had a distinguished career in the Federal Army during the American Civil War of 1861-5. His mineral collection, formed as a hobby during many years, is a remarkable one. He could pay high

prices for the best and finest specimens, and he made a special effort to represent every known species (even mere names), although some of these are very insignificant and not at all beautiful to look upon. The writer had the privilege of visiting Colonel Roebling and his collection at Trenton, N.J., in 1924, and was much struck, not only by the fineness and completeness of the collection, but also by the keenness of the venerable collector. It was remarkable how he knew and remembered every individual specimen, and he prided himself on being able to find immediately any obscure mineral that was called for. The vast amount of material, often original material that he had acquired by exchange, was freely placed at the disposal of scientific workers; for example, there are frequent mentions of the Roebling collection in E. S. Larsen's book (1921) on the optical data of minerals. The mineral collection of some 16,000 specimens was left to his son, Mr. John A. Roebling, who soon afterwards generously presented it, together with an endowment fund of \$150,000, to the United States National Museum (Smithsonian Institution) at Washington, D.C., where it will be carefully preserved and available to future workers. He wrote a book on suspension bridges, but modestly refrained from publishing his observations on minerals. He was an excellent correspondent and wrote long and interesting letters in a very small neat hand. He had no use for writing-machines—nor for automobiles. In February, 1926, he gave a very generous endowment of \$45,000 to the Mineralogical Society of America as an aid to the publication of the 'American Mineralogist'. The mineral roeblingite, a curious combination of calcium and lead silicate and sulphite, from Franklin Furnace, New Jersey, was named after him by S. L. Penfield and H. W. Foote in 1897; a good specimen of this mineral was given by him to the British Museum collection. He died at his mansion in Trenton, New Jersey, on July 21, 1926, at the age of 89. (Obituary notice by A. H. Phillips in *Amer. Min.*, 1927, vol. 12, pp. 64-67, with portrait. Some account of the Roebling mineral collection is given in *Science*, New York, 1927, vol. 65, pp. 55-56.)

СМОИЛОВ (Yakov Vladimirovich), СМОЙЛОВ (Яков Владимирович) [1870-1925], Russian mineralogist, was born at Odessa and graduated at the University there in 1893. He then became assistant in mineralogy under V. I. Vernadsky in the University of Moscow, and succeeded E. S. Fedorov in 1905 as Professor of Mineralogy and Geology in the Agricultural School near Moscow. Later he was also Professor in the University, and held many official posts in connexion with the develop-

ment of mineral resources.



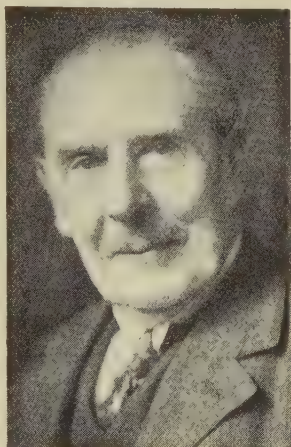
Y. V. SAMOILOV.

He was the author of many mineralogical papers on baryte, celestine, iron-ores (including hydrohaematite and hydrogoethite), &c., some of which were translated (under the name J. Samojloff) in German journals, and a suggestive paper, 'Palaeophysiology: the organic origin of some minerals occurring in sedimentary rocks', appeared in this Magazine (1917, vol. 18, pp. 87-98). He wrote a text-book on crystallography (Moscow, 1906) and edited the series of volumes 'Report on the geological investigations of the phosphate deposits' (in Russian, Moscow, vol. 1, 1909). He died on September 29, 1925. (Obituary notice in *Mineral Resources and their Technology* (Russ.), Moscow, 1926, vol. 1, pp. 177-179, with portrait.)

SMOLAŘ (Gotthard) [1863-1926], a school teacher in Bohemia, was born at Jičín (= Gitschín) on May 4, 1863, and died at Prague in June, 1926. He was the author of several papers written in Czech and German on mathematical crystallography, with especial reference to the calculation of twinned crystals. He also devised a vertical illuminator as an accessory to the goniometer for the purpose of obtaining reflections from the faces within re-entrant angles.

SOILY (Richard Harrison) [1851-1925], for several years Demonstrator in Mineralogy in the University of Cambridge, was born in London on September 4, 1851, and died at Bournemouth on December 5, 1925. His father, Samuel Solly, F.R.S., was for many years chief surgeon and lecturer at St. Thomas's Hospital, and five other members of the family (including two other Samuel Sollys and one Richard H. Solly) were elected Fellows of the Royal Society. Coming of such a distinguished family he naturally turned to science, though not at first, for after being educated at Brighton College he gained some business experience in the City. He afterwards studied at the Royal School of Mines in Jermyn Street, and in 1878-80 was employed as an unofficial worker in the Mineral Department of the British Museum (then in the old building at Bloomsbury). There, under the guidance of L. Fletcher, he prepared careful and detailed crystallographic catalogues of the

large series of blende and galena which still remain unpublished. He was elected a member of the Crystallogological Society in 1878, coming into the Mineralogical Society in 1883, and serving on its Council in 1888-91 and 1903-6. In 1880 he went to Cambridge as private assistant to W. J. Lewis, then acting as Deputy Professor, and in 1883 was appointed Demonstrator in Mineralogy. In 1888 he was awarded the honorary degree of M.A. As a teacher he was most conscientious and thorough and always ready to help a student who wished to know more of the subject. Elaborate notes were prepared and distributed for his demonstrations, and these were afterwards published as a book, 'An elementary introduction to mineralogy' (1894). This book, having been published without the consent of the Professor, unfortunately led to his resignation. He afterwards for some years lived abroad in Switzerland and Italy, frequently visiting the Binnenthal with the object of collecting new and rare minerals. Returning to England, he settled first at Malvern and afterwards at Bournemouth.



R. H. SOLLY (in 1923).

His most important work was on the minerals of the Binnenthal in Switzerland, especially the rare metallic minerals from the Lengenbach quarry, which he visited at every opportunity. There he discovered and described in the pages of this Magazine the species *baumhauerite*, *bowmanite* [= *hamlinite*], *hatchite*, *hutchinsonite*, *legenbachite*, *liveingite*, *marrite*, *smithite*, and *trechmannite*. Most of the best material he collected is preserved in the British Museum collection. He also undertook a revision of other Binnenthal minerals in a series of papers, 'Sulpharsenites of lead from the Binnenthal', commenced in 1900, and translated into German in the 'Zeitschrift für Krystallographie und Mineralogie'. All this work was done privately, and careful measurements were made of the complex crystals on his own Fuess goniometer. In addition to 24 of his papers published in this Magazine, which are listed in full in the General Indexes to vols. 1 to 20, the following appeared in other journals :

Crystallographic notes. [*Euchroite*, *orthoclase*, *gahnite*.] *Proc. Cambridge Phil. Soc.*, 1883, vol. 4, pp. 407-408.

Crystallographic examination of the crystals of antimonio-potassic chlorobromide. *Journ. Chem. Soc.*, 1883, vol. 43, p. 293.

Apatite from Levant mine, Cornwall. *Trans. R. Geol. Soc. Cornwall*, 1886, vol. 10, pp. 240-244.

[Crystallography of muconic acid.] *Journ. Chem. Soc.*, 1890, vol. 57, pp. 942-944.

Liveingite, a new mineral from the Binnenthal. *Proc. Cambridge Phil. Soc.*, 1901, vol. 11, pp. 239-240.

Notes on minerals from the Lengenbach, Binnenthal. *Nature*, 1901, vol. 64, p. 577.

On some minerals from the Binnenthal, Switzerland. *Proc. Cambridge Phil. Soc.*, 1904, vol. 12, p. 277.

A preliminary description of three new minerals and some curious crystals of blende from the Lengenbach quarry, Binnenthal. *Rep. British Assoc.*, 1905, for 1904, p. 563.

TANNHÄUSER (Felix) [1874-1924], extraordinary Professor of Mineralogy and Petrology in the Technical High School at Charlottenburg, Berlin, died on December 2, 1924. He graduated at Berlin in 1904 with a dissertation on the volcanic rocks of Ecuador. He also wrote on volcanic rocks from Argentina and gabbroid rocks from Neurolde in Silesia. In connexion with his work on the crystallography of organic compounds he detected in 1906 the existence of circular polarization in orthorhombic-sphenoidal crystals of α -methylmorphimethine.

TARASENKO (Vasily Efimovich), Тарасенко (Василий Ефимович) [1859-1926], was born at Odessa on March 7 (old style), 1859, and died at Voronezh on July 25, 1926. He completed his education at the University at Kiev in 1883, remaining there as assistant to the professor, curator of the mineral collection, and later lecturer in petrography. In 1905 he became Professor of Mineralogy in the University of Dorpat (=Yuriev), and he removed with that University to Voronezh in Central Russia in 1918. His work was on the petrography and mineralogy of the great plateau of crystalline rocks in south-west Russia. He gave in 1900 a long dissertation on the chemical composition of the plagioclase feldspars from the gabbros of Volhynia and Kiev; and in 1903 described the amphiboles from the crystalline schists of the Krivoy-Rog iron-ore district, returning to this subject in 1925 [*Min. Abstr.*, vol. 3, p. 85].

TRAVERSO (Giovanni Battista) [1843-1914], mining engineer of Genova, wrote on the minerals of Sardinia, and a Sardinian mineral was named traversoite after him in 1924. (Obituary by A. Pelloux,

Ann. Mus. Civico Storia Nat. Genova, 1914, vol. 46 (= ser. 3, vol. 6), pp. 183-192, with portrait and bibliography.)

VIOJA (Carlo Maria) [1855-1925] was born at Zara in Dalmatia, his father, a sea-captain, belonging to Fiume and his mother being a Venetian. He was educated in Dalmatia, Istria, Graz, Vienna, and Rome, graduating from the last place as civil engineer in 1880. The next three years he attended the Mining Academy in Berlin with a scholarship from the Italian Corps of Mines, and until 1885 did work on the Prussian Geological Survey. Returning to Italy, he was appointed Geologist-Engineer, working on irrigation schemes and geological mapping, and afterwards Mining-Engineer. In 1900 he was Chief Engineer of the Iglesias mining district and Director of the School of Mines there. For many years he spent his summer holidays studying crystallography with Groth in Munich and Goldschmidt in Heidelberg; and at the age of 50 he was at last able to devote himself entirely to this work, being in 1905 appointed to the Professorship of Mineralogy in the University of Parma. There, in addition to crystallography and mineralogy, he also lectured on geology, physics, geometry, and higher mathematics. He was an Honorary Member of our Society since 1912. (Mario Ferrari, 'Prof. Ing. Carlo Maria Viola†', Zeits. Krist., 1926, vol. 64, pp. 260-264.)

VULF (Georgii Viktorovich), Вульф (Георгий Викторович) [1863-1925], a distinguished Russian crystallographer. In German translations of his papers his name appears as G. Wulff; in French as G. Woulf. In his early papers and when he was elected a member of the Russian Mineralogical Society in 1888 he gave his name as Юрій Викторович Вульфъ (Yurii [=George] Viktorovich Vulf).¹ He was born at Nezhin (Нежин) in govt. Chernigov on July 10 [?old or new style], 1863, and died at Moscow on December 25 [new style], 1925. He studied and graduated at the University of Warsaw, where he was afterwards assistant and later Professor of Crystallography and Mineralogy. In 1890-1 he studied in Munich under P. Groth and in



G. V. VULF.

¹ In the 1925 edition of 'Minerva' he appears in the lists and index as three individuals—G. V. Wulff, Wulf, and Vul'f.

Paris under the physicist M. A. Cornu. In 1907 he moved to Moscow as Professor of Crystallography in the University (in both the First and the Second State Universities). Many of his crystallographic papers, which show a considerable amount of originality, are available as German translations in Groth's 'Zeitschrift für Krystallographie und Mineralogie'. They deal with the pyro-electrical and optical properties of quartz, the optical properties (and anomalies) of pseudo-symmetric crystals and of isomorphous (mixed) crystals, the theodolite method of goniometry, the growth and solution of crystals, liquid crystals, &c. He issued a stereographic net of 10 cm. radius which came to be known as the 'Wulff net', and this name has often been extended to stereographic nets in general. But it must not be forgotten that a good stereographic net (of 14.6 cm. radius) was published by A. Metius in 1633 [see *Min. Mag.*, 1908, vol. 15, p. 106.] (Obituary notice by E. Flint in *Mineral Resources and their Technology* (Russ.), Moscow, 1926, vol. 1, pp. 179-181, with portrait.)

WATSON (Thomas Leonard) [1871-1924], Professor of Geology in the University of Virginia and Director of the Geological Survey of Virginia, was born at Chatham, Virginia, on September 5, 1871, and died at Charlottesville, Va., on November 10, 1924. Educated in his native State, he also studied at Cornell University (Ph.D., 1897), and worked on the Geological Surveys of Georgia and North Carolina. He published numerous reports and papers on the mineral resources and economic geology of the south-eastern States. In accounts of the rutile deposits of Virginia nelsonite was described as a new rock type. With H. Ries he was joint-author of a text-book, 'Engineering Geology' (1914; 3rd edit., 1925). Several of his mineralogical papers appeared in the 'American Mineralogist'. (Obituary notices by H. Ries in *Bull. Geol. Soc. Amer.*, 1925, vol. 36, pp. 116-128, with portrait and bibliography of 142 items; *Amer. Min.*, 1925, vol. 10, pp. 54-57, with portrait.)

WEIBULL (Kristian Oskar Mats) [1856-1923], usually known as Mats Weibull, was born at Starbo in Dalarne on December 23, 1856, and died at Stockholm on May 26, 1923. During 1881-6 he was docent in mineralogy in the University of Lund, and afterwards taught agricultural chemistry in the Agricultural Institute at Alnarp, becoming rector in 1911 and retiring in 1922. Up to 1900 he wrote several papers on Swedish minerals and on the crystallography of organic compounds; since that date his work was on soils. A notable contribution was on the chemical composition of idocrase in 1895. He gave the mineral names igelströmite, manganhedenbergite, mangan-

hisingerite, and silfbergite. A mineral which he described in 1885 as a seleniferous variety of galenobismutite has since been called weibullite. (Obituary by G. Aminoff in *Geol. För. Förh.* Stockholm, 1924, vol. 46, pp. 692-695, with portrait and bibliography.)

WELLS (Horace Lemuel) [1855-1924], American chemist, was born on October 5, 1855, at New Britain, Connecticut, and died on December 19, 1924, at New Haven, Connecticut. He graduated in chemistry in 1877 at the Sheffield Scientific School of Yale University, and after a few years as works chemist, he returned in 1884 to New Haven as instructor in analytical chemistry, becoming later (1893-1923) professor of analytical chemistry and metallurgy. There he was associated with G. J. Brush, E. S. Dana, and S. L. Penfield, and his early work was mineralogical. He described sperrylite as a new mineral in 1889, gerhardtite in 1885 (with S. L. Penfield), and beryllonite in 1889 (with E. S. Dana). His analysis of pollucite from Hebron, Maine, led to his well-known work on the compounds of caesium. Since 1904 he was an associate editor of the 'American Journal of Science', to which he contributed a large number of excellent reviews on chemical subjects. The zeolite wellsite bears his name. (H. W. Foote, *Amer. Journ. Sci.*, 1925, ser. 5, vol. 9, pp. 189-194, with portrait and bibliography.)

WILLIAMSON (Erskine Douglas) [1886-1923], physical chemist, was born at Edinburgh on April 10, 1886, and died at Washington, D.C., on December 25, 1923. He graduated at the University of Edinburgh (B.Sc. 1908, M.A. 1909) and was a research assistant to Sir James Walker under the Carnegie Trust. In 1914 he joined the staff of the Geophysical Laboratory of the Carnegie Institution of Washington. There, with the aid of elaborate apparatus, or rather machinery, he studied the physical and chemical effects of very high pressures, and measured the compressibilities of minerals and rocks. He also worked on the various forms of calcium carbonate and the conditions of their formation. During the war he was at glass works, superintending the manufacture of optical glass. (Obituary notice in *Journ. Washington Acad. Sci.*, 1924, vol. 14, p. 42.)

TSCHERMAK (Gustav von) [1836-1927], the veteran Austrian mineralogist, died on May 4 at the age of 91.

Rotating crystal X-ray photographs.

By GILBERT GREENWOOD, M.Sc.

[Read March 15, 1927.]

SINCE the original experiments of M. von Laue on the diffraction of X-rays by crystals, other and more suitable methods of research have been devised. The Bragg ionization-chamber method and the Debye-Scherrer powder method are now quite well known. The newest technique is that of the so-called 'rotating crystal', which is based essentially on some experiments of M. de Broglie.¹ This method was first employed and developed in the Kaiser Wilhelm Institut für Faserstoffchemie in Berlin. It has recently been extended by the work of J. D. Bernal² in the Royal Institution in London.

There are two methods of making this type of photograph. In both a small crystal is rotated in a beam of X-rays and the reflected beams recorded photographically, in one case on a flat plate, and in the other on a cylindrical film the axis of which coincides with the axis about which the crystal is rotated. Usually the crystal is rotated about an important zone-axis. In the first case, the spots on the plate lie on hyperbolae, whilst in the second case the spots are arranged along straight lines running horizontally round the film. These lines have been called 'Schichtlinien'—'layer-lines'. In this paper the latter type of photograph only is considered.

This method seems to be particularly well adapted for the study of more purely crystallographic problems, in distinction to determinations of crystal-structure. The difference lies essentially in the fact that this method measures so easily the identity period (or true unit-cell dimension) in the direction of the axis of rotation, whilst in the other methods a spacing is measured. In these cases the unit-cell dimensions must be

¹ M. de Broglie, *Compt. Rend. Acad. Sci. Paris*, 1913, vol. 157, pp. 924 and 1413; 1914, vol. 158, p. 177.

² J. D. Bernal, *Proc. Roy. Soc. London, Ser. A*, 1926, vol. 113, p. 117.

obtained indirectly. The indices of the reflecting planes, giving rise to the spots on the photographs, can be found, and from statistical data obtained in this way the space-group in which the substance crystallizes can often be determined. Cases frequently occur where only the crystal-system and not the particular class can be determined by crystallographic measurements. If, in such cases, the space-group can be fixed unequivocally, then the crystal-class and at the same time the symmetry-elements of the crystal are determined. A further instance of the rotating crystal photograph as an aid in the investigation of symmetry may be given. Consider an axis of n -fold symmetry, where a certain doubt exists as to the value of n . Arranged round this axis are n equivalent faces ($h\ k\ l$) and, if the crystal is rotated about this axis, the spot on the photograph to which the indices ($h\ k\ l$) are assigned consists of n superimposed spots. Now let the crystal be rotated about a direction which nearly but not quite coincides with this axis. Then each spot on the film is split up into its n constituents, and the order of the axis is found by counting the number of these constituent spots.

The identity period is very simply related to the distance between the 'layer-lines'. This relationship seems to have been first obtained in a somewhat complicated manner in a series of papers by M. Polanyi and K. Weissenberg.¹ It may be obtained as follows, by a simple type of reasoning which, when applied to spacings, gives the Bragg equation. Here it is applied to identity periods. In fig. 1 let abc be the direction of rotation and let a, b, c , &c., be the lattice points which are equivalent along this line, i.e. the distances between these points are equal to the primitive translation in this direction. Let it be I . Let X-rays of wave-length λ fall on this string of points. Radiation is diffracted from the points in all directions. Consider the direction cd which makes an angle μ with the incident beam. The phase-difference between the rays from b and c is ec , and a reflected beam is obtained in the direction cd when this difference is a multiple of λ . Hence

$$n\lambda = ec = bc \sin \mu = I \sin \mu, \text{ or } I = n\lambda / \sin \mu.$$

If the beam cd gives rise to the first layer-line, then $n = 1$. For the second layer-line $n = 2$, and so on.

Let the vertical dotted line be the section of the cylindrical film of radius r , and let $2e$ represent the distance between the layer-line and the corresponding one on the lower half of the film. Then $\tan \mu = e/r$. Hence I can be determined.

¹ M. Polanyi, *Zeits. Physik*, 1921, vol. 7, p. 149; M. Polanyi and K. Weissenberg, *ibid.*, 1922, vol. 9, p. 123; 1922, vol. 10, p. 44.

J. D. Bernal has carried out a complete mathematical investigation of the reflection of X-rays by rotating crystals, under the various forms of experiment, by the use of the conception of the reciprocal or polar lattice, an idea which seems to date back to the time of Bravais.¹ On pages 133, 134, and 148 of his paper the above results appear in a slightly different form.

The assignment of indices to the individual spots was carried out in the German Laboratories in the following way. A measured value of

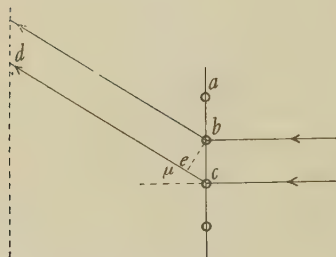


FIG. 1.

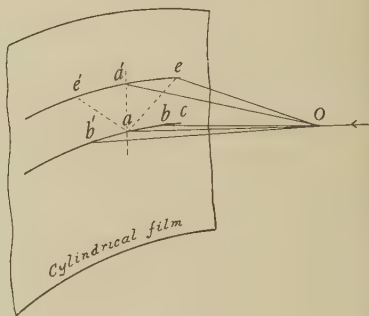


FIG. 2.

$\sin^2 \theta$ obtained from the film was compared with the values of $\sin^2 \theta$ for the planes which could give rise to a reflection lying on the layer-lines in question. Let the direction of the axis of rotation be $[u \ v \ w]$, then it has been shown² that any plane $(h \ k \ l)$ which gives rise to a reflection spot on the n th layer-line must obey the relation $hu + kv + lw = n$.

Knowing the possible planes and the unit-cell dimensions, the theoretical values of $\sin^2 \theta$, where θ is the glancing angle, can be calculated. The measurement of the experimental value of $\sin^2 \theta$ is as follows. Let $a \ b \ c$, fig. 2, represent the equatorial line of spots, i.e. reflections from planes parallel to the axis of rotation. At the point O , the centre of the camera, is the crystal, and reflection occurs here. Consider a particular spot at b and the corresponding one on the other side at b' , then the angular distance $b \ b'$ is equal to 4θ . Now consider a spot e in the first layer-line. Let the angle $e \ a'$, which is easily measured on the film (equal to half $e \ e'$), be α . The angle $a' \ o \ a$ is equal to μ , whilst the angle between the primary beam $o \ a$ and the reflected beam $o \ e$ equals 2θ . These angles form the sides of a right-angled spherical triangle, and we

¹ A. Bravais, *Études cristallographiques*, Paris, 1866, p. 103.

² Perhaps the most satisfactory proof of this fact is that given by J. D. Bernal on p. 148 of his paper.

obtain $\cos 2\theta = \cos a \cos \mu$. Remembering that $\sin^2 \theta = \frac{1}{2} (1 - \cos 2\theta)$ and calculating in tabular form, $\sin^2 \theta$ is very easily got from the length ee' .

J. D. Bernal has developed a method of assigning indices by projecting the film or flat plate, magnified up to the correct size, on to suitably constructed charts, when the indices can be read off. Accurate crystal adjusting arrangements and precision cameras have been devised, and the spots then fall exactly on the correct places on the charts.

In making the photographs about to be described, a Hadding tube was used. This type of tube was found to work very well. The anticathode is easily interchangeable, and in some photographs Cu- and in others Fe-radiation was used. The high voltage applied to the tube was obtained from a transformer working in conjunction with a mechanical rectifier. Both the anticathode and cathode were water-cooled; the latter, being at a high potential, required an insulated system. The camera was an ordinary Debye-Scherrer camera of the original pattern. Instead of a rod of crystal powder being supported inside, the small crystal was mounted on a goniometer head, attached to a spindle, which was arranged so as to be rotated by an external motor. The diameter of the camera was 5.72 cm.

Tetra-methyl-ammonium iodide $N(CH_3)_4I$.

According to F. Slavík¹ this substance crystallizes in the tetragonal system with an axial ratio of $a : c = 1 : 0.723$, and although the crystal-class is usually said to be bipyramidal, no very definite proof of this has been given.

Rotation photographs were made, in which the directions, about which the crystals were rotated, were $[001]$, $[100]$, and $[110]$. The first two photographs were made with Cu-radiation and the third with Fe-radiation. The results obtained for the identity periods, from measurements of the layer-lines, are given in the following table.

Table I.

Rotation about $[001]$ using Cu-radiation.			Rotation about $[100]$ using Cu-radiation.			Rotation about $[110]$ using Fe-radiation.		
$2e$.	μ .	I .	$2e$.	μ .	I .	$2e$.	μ .	I .
1.6 cm.	15.6°	5.73 Å.	1.1 cm.	10.9°	8.14 Å.	1.0 cm.	9.9°	11.3 Å.
3.6	32.2	5.78	2.35	22.4	8.08	2.1	20.2	11.2
			4.1	35.7	7.92	3.5	31.5	11.1
		Mean = 5.75			Mean = 8.05			Mean = 11.20

¹ F. Slavík, Zeits. Kryst. Min., 1902, vol. 36, p. 273.

The axial ratio as calculated from these values is $a:c = 1:0.715$, which agrees with the above crystallographic data.

In all tetragonal crystals there are two alternative orientations possible for the a -axis. This depends on the fact that the translation group Γ_t may be regarded either as a simple or as a base-centred tetragonal prism, according to whether the side or the diagonal of the square base is made the a -axis. In exactly the same way the translation group Γ'_t may be regarded as a centred, or a face-centred tetragonal prism. In the tables of Astbury and Yardley¹ these four possibilities are made clear by comparison with the analogous orthorhombic groups Γ_o , Γ_o' , Γ_o'' , and Γ_o''' . In most space-group tables the shortest identity period in the plane (001) is chosen as a -axis, i. e. the translation-groups are regarded either as a simple or a centred tetragonal lattice. Crystallographic measurements give no criterion for fixing the axial directions, and if necessary the axes chosen and the indices assigned by the crystallographer must be altered. A difficulty arises, however, with regard to the scalenohedral space-groups. From the external symmetry the axial directions are taken as fixed, and this causes the groups V_d^5 to V_d^8 to be based on a base-centred lattice, and V_d^9 and V_d^{10} on a face-centred lattice. In the determination of space-groups from reflection data, this must not be overlooked.

The second and third photographs show that the identity periods in the crystallographic directions [100] and [110] are 8.05 Å. and 11.20 Å. Hence the crystallographic axes coincide with the structural axes used in mathematical crystallography, and no changes are required. The value of $I_{[110]}$ calculated from $I_{[100]}$ is 11.30 Å. Using the known value of the density 1.835, the molecular weight of the substance, and the size of the unit-cell, it is possible to calculate the number of molecules in this unit. It is found to be *two*. A further analysis of the photographs was now carried out, and the indices of the reflecting planes assigned to the appropriate spots on the photographs. The glancing angle θ is given by the quadratic form, which in the case of tetragonal crystals is:

$$\sin^2 \theta = \frac{\lambda^2}{4} \left(\frac{h^2 + k^2}{a^2} + \frac{l^2}{c^2} \right).$$

For the photographs made with Cu-rays it becomes:

$$\sin^2 \theta = 0.0093 (h^2 + k^2) + 0.0179 l^2$$

whilst in the case of Fe-radiation it is:

$$\sin^2 \theta = 0.0147 (h^2 + k^2) + 0.0284 l^2.$$

¹ W. T. Astbury and K. Yardley, Phil. Trans. Roy. Soc. London, Ser. A, 1924, vol. 224, p. 221.

In tables II, III, and IV the results from the films obtained by rotating about the directions $[001]$, $[100]$, and $[110]$ are given. In all cases the value $\sin^2 \theta$ for the particular reflection is calculated as described in the introductory section, and this is compared with the theoretical value calculated from the quadratic form and thus the indices are found. In some cases the measured value agrees equally well with the $\sin^2 \theta$ calculated for two planes ; if this occurs both indices are given. Sometimes, especially in systems with a high degree of symmetry, two different planes may have the same spacing, and then the interference spots will coincide. The two indices are again given.

Table II.

 Rotation about $[001]$. Cu-radiation.

	Points without alternative indices.	Points with alternative indices.
Equator. $l = 0$.	200, 220, 130, 400, 240, 440. 350, 600, 260, 460, 370, 800. 280, 660, 480, 190, 390.	(140, 330), (550, 170). (380, 570), (500, 340, 150). (10.0.0, 680, 1.10.0).
1st Layer-line. $l = 1$.	101, 111, 201, 121, 221, 301. 131, 231, 401, 141, 241, 251. 351, 601, 261, 701, 461, 371. 281, 481, 191, 581.	(501, 341), (381, 571). (801, 471, 181). (671, 291).
2nd Layer-line. $l = 2$.	202, 232, 402, 252, 602, 362. 702, 462, 562, 802, 662. 582.	(222, 302), (502, 342). (262, 452) (482, 902). (672, 292).

Table III.

 Rotation about $[100]$. Cu-radiation.

	Points without alternative indices.	Points with alternative indices.
Equator. h (or k) = 0.	200, 201, 102, 400, 303, 104.	(204, 600).
1st Layer-line. h (or k) = 1.	111, 102, 112, 150, 151.	(103, 141).
2nd Layer-line. h (or k) = 2.	211, 220, 240, 233, 224.	—
3rd Layer-line. h (or k) = 3.	321, 331, 333, 352.	(303, 332), (342, 350).

Table IV.
Rotation about [110]. Fe-radiation.

	Points without alternative indices.	Points with alternative indices.
Equator. $h-k = 0$.	110, 111, 220, 221, 331, 441. 442, 115, 551, 552, 444.	(223, 332).
1st Layer-line. $h-k = 1$.	211, 320, 213, 430, 104. 324, 105, 543.	(432, 214).
2nd Layer-line. $h-k = 2$.	201, 311, 204, 531, 423. 532, 205, 641.	(315, 642).
3rd Layer-line. $h-k = 3$.	210, 411, 303, 214, 522. 414, 215.	—

A certain amount of difficulty is experienced in the investigation of this substance, owing to the iodine in the molecule, which liberates fluorescent iodine radiation. This fluorescent radiation gives rise to a general blackening and fogging of the film. In the second film (Table III) this was especially marked, in fact the two ends of the film were so black that it was impossible to make any measurements of the large angles of deflection that occur in this region.

The following table has been constructed as a summary of the preceding data, and gives details of the halvings of different types of planes. None of the points to which alternative indices could be assigned have been used.

Table V.

(hkl)	All normal, even when $(h+k+l)$, $(h+k)$, $(k+l)$, or $(k+h)$ is odd.
(hhl)	All normal whatever value of h , l , or $(h+l)$.
($hh0$)	Normal.
(hkl)	All normal, even when $(h+k)$ is odd, except 280. The first order, however, of this plane—140—occurs as a possible index for another interference point.
(100)	Halved. The reflections 200, 400, 600, and 800 occur. No trace of 100, 300, 700, or 900 could be found.
(001)	No data could be found. A spectrometer investigation was therefore made for me by Mr. R. W. James, to whom I take this opportunity of expressing my thanks. A reflection 100 was found, whilst no trace of 200 could be found. This plane is therefore normal.

Consideration must now be given to the points with alternative indices. In all cases except a possible 500 the conclusion of the above table that

(100) *only* is halved is not contradicted. There are, however, two possible alternatives to account for this reflection and neither of these contradicts the statement of halving.

Tetra-ethyl-ammonium iodide, $N(C_2H_5)_4I$.

F. Slavík¹ describes this substance as crystallizing in the scalenohedral class of the tetragonal system, i. e. having ditetragonal alternating symmetry. The value given for the axial ratio is $a:c = 1:0.5544$. Crystals exhibit a well-marked scalenohedral form. According to conventional crystallographic usage the axial directions are therefore fixed, coinciding with the directions of the twofold symmetry axes which are determined by the scalenohedral symmetry. Identity periods in the crystallographic directions [001], [100], and [110] were measured with the following results.

Table VI.

Rotation about [001] using Fe-radiation.			Rotation about [100] using Cu-radiation.			Rotation about [110] using Cu-radiation.		
<i>2c.</i>	μ .	<i>I.</i>	<i>2c.</i>	μ .	<i>I.</i>	<i>2c.</i>	μ .	<i>I.</i>
1.7 cm.	16.6°	6.78 Å.	0.72 cm.	7.2°	12.30 Å.	1.0 cm.	9.9	8.97 Å.
3.7	34.3	6.87	1.5	14.7	12.15	2.15	20.6	8.75
			2.3	21.9	12.40			
			3.3	30.0	12.30			
		Mean = 6.82			Mean = 12.29			Mean = 8.86

This shows that, using the crystallographic axial directions, the type of lattice underlying the structure is a base-centred one. If, however, the [100] and [110] directions were to be interchanged, the structure would be based on a lattice with a simple square base. It is usual in tetragonal space-groups to refer the structure to such axes, but in this case, since there is strong evidence from the symmetry of the crystal that the crystallographic axes are correct, these axes will be adopted in the evaluation of the diagrams.

Using the dimensions $a = 12.29$ Å. and $c = 6.82$ Å. (which give an axial ratio of $a:c = 1:0.555$) and the value 1.566 for the density,

¹ F. Slavík, *Zeits. Kryst. Min.*, 1902, vol. 36, p. 274.

calculation shows that this unit-cell contains *four* molecules. The quadratic forms for the two wave-lengths used become :

$$\text{Fe-rays :—sin}^2\theta = 0.0062 (h^2 + k^2) + 0.0201 l^2.$$

$$\text{Cu-rays :—sin}^2\theta = 0.0039 (h^2 + k^2) + 0.0127 l^2.$$

The results obtained by the measurements of the photographs are given in the following tables.

Table VII.

Rotation about [001]. Fe-radiation.

	Points without alternative indices.	Points with alternative indices.
Equator. $l = 0$.	220, 330, 400, 280, 570.	(700, 170, 550).
1st Layer-line. $l = 1$.	111, 131, 441, 371, 281. 481.	(400, 331), (551, 171, 701). (341, 501).
2nd Layer-line. $l = 2$.	222, 402, 332, 442.	(202, 122). (162, 262).

Table VIII.

Rotation about [100]. Cu-radiation.

	Points without alternative indices.	Points with alternative indices.
Equator. h (or k) = 0.	102, 400, 202, 204.	(801, 404).
1st Layer-line. h (or k) = 1.	112, 113, 153.	(152, 133, 161). (164, 135).
2nd Layer-line. h (or k) = 2.	260, 224, 225.	(240, 222), (242, 203). (263, 281).

In the interpretation of the third photograph an important and interesting point must be considered. The indices and the quadratic forms refer to a unit of size $6.82 \times 12.29 \times 12.29$ Å. The diagonal of the base of such a unit is 17.38 Å. The diagonal is actually found to be half this. The result of this is that the 1st, 3rd, 5th, &c., layer-lines disappear. This must, however, not be overlooked in assigning indices to the interference points. The apparent first layer-line is really the second and the relation $hu + kv + lw = 2$ must be applied.

Table IX.

Rotation about [110]. Cu-radiation.

	Points without alternative indices.	Points with alternative indices.
Equator. $h-k=0$.	111, 220, 221, 002, 442, 224. 661, 005.	(222, 331). (003, 332, 113).
1st Layer-line. $h-k=2$.	200, 112, 202, 420, 113, 531. 314, 424, 643, 752.	(114, 641), (860, 425).
2nd Layer-line. $h-k=4$.	221, 400, 223, 731, 404. 225.	(401, 222), (402, 511), (622, 513).
3rd Layer-line. $h-k=6$.	511, 332, 422, 711, 334.	—

Summarizing the data obtained from the points without alternative indices we get the following table.

Table X.

(hkl).	Planes of this type do not occur in the first order, i.e. they have halved spacings when ($h+k$) is odd.
(hhl).	All normal whatever values of h , l , or ($h+l$).
($h h 0$).	Normal.
($h k 0$).	Halved if ($h+k$) is odd; this is a special case of (hkl).
(001).	Normal.
(100).	Halved; again a special case of (hkl).

Considering now the points possessing doubtful indices, we find certain points—700, 701, 122, 162, and 161—which would contradict the conclusion to be drawn from Table X—that *planes (hkl) are halved when ($h+k$) is odd*. In all these cases, however, one of the alternative interpretations can be found, which is in agreement with the above-stated condition. This condition is expressed in terms of a base-centred lattice: when expressed in terms of a simple tetragonal lattice it becomes *all spacings are normal*.

Determination of the Space-groups of $N(CH_3)_4I$ and $N(C_2H_5)_4I$.

Most of the space-group tables give the abnormalities of spacings in terms of simple and centred tetragonal lattices as fundamental units. Astbury, however, often gives these same abnormalities when the structure is referred to base-centred and face-centred units. This has not been done, however, for certain groups of the scalenohedral class. In order to complete the data on the halving of spacings in groups of the tetragonal

system when referred to the simplest tetragonal unit, the peculiarities of groups V_d^5 to V_d^{10} referred to this simple unit are given in Table XI.

Table XI.

Space-group.	Abnormal spacing.
V_d^5 ...	None.
V_d^6 ...	($h0l$) when l is odd.
V_d^7 ...	($h0l$) when h is odd.
V_d^8 ...	($h0l$) when $(h+l)$ is odd.
V_d^9 ...	(hkl) when $(h+k+l)$ is odd.
V_d^{10} ...	{ (hkl) when $(h+k+l)$ is odd. ($h0l$) when l is odd.

$N(CH_3)_4I$.—Certain space-groups can be definitely excluded owing to the occurrence of reflections, whilst other groups are only excluded by the absence of certain reflections. By means of the presence of reflections all groups are excluded except V_d^1 , V_d^5 , S_4^1 , C_4^1 , C_{4h}^1 , C_{4v}^1 , D_4^1 , D_{4h}^1 , D_4^2 , and V_d^3 . In the first eight of these, however, odd orders from (100) should occur: these were not found. Hence these groups may be eliminated, but this elimination is not so rigid as that based on the presence of certain reflections. Crystallographic evidence on the external symmetry does not help in the determination of the crystal-class, i. e. deciding between D_4 and V_d , since only holohedral forms have been observed. The corresponding tetra-ethyl-ammonium salt crystallizes (as will be shown in the next paragraph) in the class V_d . Hence, having regard to the similarities of the two substances, the evidence seems to be in favour of V_d^3 as the space-group in which tetra-methyl-ammonium iodide crystallizes.

As far back as 1917 an X-ray investigation of this substance was made by L. Vegard,¹ who measured the spacings of the planes (100), (110), (001), (101), and (111) and obtained a unit-cell of dimensions $a = 7.88$, $c = 5.69$ Å., in which the spacing of the (100) planes is halved. When this unit-cell is recalculated, using modern values of the wave-length of the X-rays, the size of the unit-cell becomes $a = 7.97$ and $c = 5.74$ Å. These experimental results are thus in agreement with those obtained from the rotation photographs. L. Vegard (loc. cit., p. 402), as a result of his measurements brings forward a structure which possesses 'the highest degree of symmetry'. The mathematical theory of space-groups, which was not well known to X-ray analysts at that early date, shows at once that any tetragonal crystal which gives the results described above,

¹ L. Vegard, Phil. Mag., 1917, ser. 6, vol. 33, p. 395. [Min. Abstr., vol. 2, p. 507.]

cannot belong to the holohedral class. Hence the structure proposed by L. Vegard cannot be correct. Certain deductions as to the position of the atoms in the unit-cell can be made from space-group considerations, quite apart from any discussion of intensities. In the unit-cell are two nitrogen atoms, two iodine atoms, and eight CH_3 radicles. In the space-group V_a^3 , a point in the general position repeats eight times in the unit. A nitrogen atom, therefore, cannot be in such a position. Points in special positions can be found so that they give rise to only one other equivalent point. In the space-group V_a^3 there are three such pairs of equivalent points and they have the co-ordinates (000) , $(\frac{1}{2}\frac{1}{2}0)$; $(00\frac{1}{2})$, $(\frac{1}{2}\frac{1}{2}\frac{1}{2})$; and $(0\frac{1}{2}u)$, $(\frac{1}{2}0\bar{u})$. Two out of these three pairs must be occupied by the nitrogen and the iodine atoms, whilst if we assume that the CH_3 radicles are equivalent—a somewhat natural assumption—they must occupy general positions in the unit. Cases are known, however, where chemically equivalent groups or atoms are not crystallographically equivalent.¹ This may happen here, since two sets of points can be found each of which consists of four equivalent points. In this case the CH_3 radicles would be of two types. The nitrogen atoms must, however, be of the same type since no point can be found, which by operation of the symmetry elements does not give rise to at least one equivalent point. The same also applies to the iodine atoms.

$N(\text{C}_3\text{H}_5)_4\text{I}$.—Using the simple tetragonal unit we find no abnormal spacings and conclude from the X-ray evidence that the possible space-groups are V_a^1 , V_a^5 , S_4^1 , C_4^1 , C_{4h}^1 , C_{4v}^1 , D_4^1 , and D_{4h}^1 . Crystallographic evidence is strongly in favour of scalenohedral symmetry and thus would point to the groups V_a^1 and V_a^5 as being most likely. All the groups except V_a^5 are based on a simple tetragonal lattice, and thus to produce a base-centred lattice the direction $[110]$ must be taken as the new a -axis. The crystallographic data again produce strong evidence that the axial directions are two-fold axes of symmetry. An examination of the space-groups shows that in certain of them the axial directions do not coincide with two-fold axes. In this way groups S_4^1 , C_4^1 , V_a^1 , C_{4h}^1 , and C_{4v}^1 , are seen to be very unlikely. The mass of evidence is therefore in favour of V_a^5 being the space-group concerned in the structure of tetra-ethyl-ammonium iodide.

¹ For example, the copper atoms and the zinc atoms in γ -brass, see A. J. Bradley and J. Thewlis, Proc. Roy. Soc. London, Ser. A, 1926, vol. 112, p. 678. The aluminium atoms in chrysoberyl are crystallographically of two types, see W. L. Bragg and G. B. Brown, Proc. Roy. Soc. London, Ser. A, 1926, vol. 110, p. 34.

In the base-centred unit-cell are four nitrogen atoms, four iodine atoms, and sixteen C_2H_5 radicles. From space-group theory we again find that all the nitrogen atoms must be equivalent, and also the iodine atoms. Three sets of four equivalent points occur, and have the co-ordinates $(00u)$, $(00\bar{u})$, $(\frac{1}{2}\frac{1}{2}u)$, $(\frac{1}{2}\frac{1}{2}\bar{u})$; $(0\frac{1}{2}u)$, $(0\frac{1}{2}\bar{u})$, $(\frac{1}{2}0u)$, $(\frac{1}{2}0\bar{u})$; $(\frac{1}{4}\frac{1}{4}u)$, $(\frac{3}{4}\frac{3}{4}u)$, $(\frac{1}{4}\frac{3}{4}\bar{u})$, $(\frac{3}{4}\frac{1}{4}\bar{u})$. Two out of these three sets must be occupied by the nitrogen and the iodine atoms. The C_2H_5 radicles may be in the sixteen general positions, or in two sets of eight equivalent positions.

The three substances, ammonium iodide, tetra-methyl-ammonium iodide, and tetra-ethyl-ammonium iodide, have been regarded as forming a series of closely related, if not strictly isomorphous compounds. Topic axes have been calculated for them, making the assumption that the same number of molecules occurred in the unit-cells, and on the basis of these topic axes P. Groth¹ has suggested hypothetical structures for the crystals. The results of X-ray analysis show that there is a different number of molecules in the units of the three substances. Ammonium iodide² has been found to have the rock-salt structure with four molecules in the unit. Tetra-methyl-ammonium iodide has two molecules in its unit, whilst in the large and more crystallographically correct unit of the tetra-ethyl salt there are four molecules. If the alternative small unit in which the base is not centred is considered, there are only two molecules in it. Making allowance for these different numbers of molecules in the units, the values shown in the table are obtained for the true topic axes. They are, of course, proportional to the actual unit-cell dimensions. The old topic axes are also shown in the table.

Table XII.

	Groth's Topic Axes.			True Topic Axes.			Unit-cell dimensions.	
	Mol. vol. V .	$\chi = \psi$.	ω .	V' .	$\chi = \psi$.	ω .	$a = b$.	c .
NH_4I .	57.51	3.860	3.860	220.04	6.04	6.04	7.20 Å.	7.20
$N(CH_3)_4I$.	108.70	5.319	3.842	217.4	6.72	4.84	8.05	5.75
$N(C_2H_5)_4I$ (a).	162.91	6.648	3.686	651.64	10.6	5.84	12.29	6.82
„ (b).	—	—	—	375.82	7.51	5.77	8.86	6.82

It is easily seen from the true topic axes that it is impossible to draw any conclusions as to the isomorphism of the three substances.

¹ P. Groth, *Chemische Krystallographie*, 1906, vol. 1, p. 171; see also S. Kreutz, *Elemente der Theorie der Krystalstruktur*, 1916, p. 145.

² L. Vegard, *Phil. Mag.*, 1917, ser. 6, vol. 33, p. 395.

In fact, these topic axes, the unit-cell dimensions, and the numbers of molecules in the unit-cells all show that the substances are not isomorphous even in a fairly wide sense of the term. It has been previously pointed out¹ that isomorphous replacement by organic radicles is by no means so common an occurrence as isomorphous replacement in the inorganic and mineral world. As a result of the crystallographic measurements on glyoxaline compounds and certain menthyl salts of a complicated carboxylic acid, it was concluded that isomorphous replacement only occurs in organic crystals when the replacement makes a comparatively small molecular change. The behaviour of the three substances here discussed is in agreement with this idea.

In conclusion, I wish to express my gratitude to the International Education Board for the grant of a Fellowship during the tenure of which this work was carried out. I am also greatly indebted to Dr. H. Mark of the Kaiser Wilhelm Institut für Faserstoffchemie in Berlin for the facilities given to make these experiments and for helpful advice during the work.

¹ G. Greenwood, *Min. Mag.*, 1925, vol. 20, p. 393.

On the occurrence of the rare mineral nadorite in Cornwall, and of beraunite in Co. Cork, Ireland.

By ARTHUR RUSSELL.

[Read November 6, 1923.]

NADORITE.

[PbClSbO_2 . Orthorhombic, $a:b:c = 0.7490:1:1.0310$.¹]

THE rare mineral nadorite has hitherto been recorded from one locality only, namely, Jebel Nador in the province of Constantine, Algeria, where at one time it was found in considerable quantity associated with bindheimite, smithsonite, and galena in a deposit lying between lacustrine limestone and brown marl.

In the present notes I am able to record the occurrence of this mineral at the small antimony mine of Bodannon, St. Endellion, Cornwall, where I found a single specimen in 1907. Immediately after the reading of this paper, Professor A. Hutchinson of Cambridge most kindly sent me a specimen for examination which he had himself collected from the small dump at Bodannon in 1919, and this mineral, which had attracted his attention, also proved to be nadorite.

The Bodannon mine is situated about a mile south-east of Port Isaac in the fields on the left-hand side of the road a little east of Trewetha. The mine was opened in virgin ground in 1906 by the late Major J. Teague, to whom, and to Captain T. H. Oliver of St. Teath, I am indebted for the help they afforded me in the look-out for any minerals of interest. The workings were so limited in extent and the mine so short lived (on account of the ore met with being entirely jamesonite, and as such unsaleable) that much cannot be said respecting the deposit. There appeared to be two distinct antimony lodes, one of which is very probably a continuation of one of those worked long since in the adjoining mine of Wheal Boys or Old Trewetha, famous as the original locality of bournonite ('endellionite'). The antimony at Bodannon was entirely in the form of jamesonite and its alteration-product bindheimite; and of the

¹ G. Cesàro, Bull. Soc. Franç. Min., 1888, vol. 11, p. 44.

former I saw in an open-cut, only 6 feet from the surface, a nearly solid pocket 8 feet wide. The only other minerals observed, in addition to those mentioned, were anglesite as small greenish crystals in cavities in the jamesonite, some chalybite, and much limonite and quartz.

Specimen no. 1 collected by myself consists of a mass of bright fibrous jamesonite externally coated with yellow somewhat resinous-looking bindheimite. Well within the unaltered jamesonite is a cavity $2\frac{1}{2} \times 1\frac{1}{2}$ cm. almost entirely filled with nadorite, the surface of which is covered with very small, though well-defined, crystals of that mineral. Penetrating the mass of the nadorite are a few small needles of jamesonite and flakes of bindheimite, the remainder of the cavity being occupied by quartz and lemon-yellow bindheimite, on both of which minerals are scattered plates of nadorite. In a small adjoining cavity are minute colourless octahedra of senarmontite.

The nadorite forms aggregates of more or less parallel, nearly square, exceedingly thin, transparent plates of a smoky brownish-yellow to reddish-brown colour with a bright adamantine somewhat resinous lustre. The largest aggregate of plates is about $1\frac{1}{2}$ mm. across and is represented in fig. 1. Under the microscope each individual plate is seen to consist of two or more crystals tabular parallel to $a(100)$ and twinned on $l(011)$. The calculated value l to l' being $91^\circ 45'$, the plates are therefore practically square in outline. A slight diagonal depression is often visible running across the plate from coign to coign. The crystals are bounded on two adjoining sides by narrow, though bright, faces of $r(130)$; these as well as $a(100)$ afford, however, banded or multiple images on the goniometer. The other two sides are seldom free, but when visible they taper away to edges and afford no evidence of definite forms. The measurements given below were obtained from four crystals from specimen no. 1, and two from no. 2.

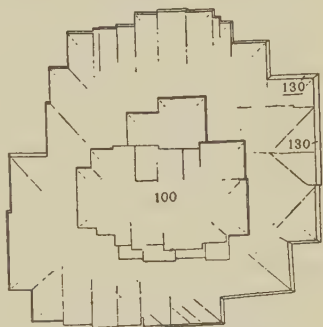


FIG. 1. Nadorite from Bodan-non mine, St. Endellion, Cornwall. Aggregate of crystals twinned on (011).

Angle.	Calculated.	Observed mean.	Limits.	No. of readings.
(100):(130) ...	$66^\circ 0\frac{1}{2}'$...	$65^\circ 5'$...	$64^\circ 10' - 66^\circ 24'$...	7
(130):(130) ...	47 59 ...	47 35 ...	44 14 - 48° 48' ...	6

The orientation and axes adopted are those of Cesàro, the letters those of Dana (sixth edition).

The cleavage is perfect parallel to $a(100)$, and the streak pale yellowish. The crystals are optically positive and show strong birefringence. The optic axial plane is parallel to $b(010)$, and the obtuse negative bisectrix perpendicular to $a(100)$. For the determination of the optical characters I am indebted to Mr. W. Campbell Smith.

In the closed tube the mineral gives a white sublimate of lead chloride. Before the blowpipe on charcoal it yields a globule of lead and a white coating of antimony oxide.

Specimen no. 2, collected by Prof. A. Hutchinson, shows an aggregate 1 cm. across of tabular nadorite crystals, the largest of which measures about $1\frac{1}{2}$ mm. in diameter, occupying a cavity in quartz and jamesonite. Adjoining cavities contain minute greenish crystals of anglesite, octahedra of senarmontite, and a little bindheimite. The nadorite crystals on this specimen are much thicker than those on no. 1, are dark reddish-brown and translucent, and both crystals and broken surfaces possess a slightly iridescent tarnish. The habit also differs somewhat from the preceding in that these crystals do not appear to be twinned, and they are six-sided rather than square in outline. In no case are more than three bounding edges exposed, while the faces of $a(100)$ and $r(130)$ are the only ones which afford reflections. The crystals further have a tendency to grouping in more or less parallel position. The faces of (130) are well developed and usually uppermost; the faces forming the remaining edges are rounded and afford no reflections, the angle between them over the edge (130) ($\bar{1}30$) determined by the maximum illumination being approximately $119^{\circ} 54'$.

Although the crystals of nadorite on these two Cornish specimens are insignificant in size compared to those from Algeria, the occurrence forms an interesting addition to the species known to Britain.

BERAUNITE.

[Hydrated ferric phosphate. Monoclinic.]

A single specimen of this mineral was found by myself in 1918 on the old dumps at the small iron and manganese mine of Roury Glen, situated between Glandore and Ross Carbery, Co. Cork. The lode here appears to be a continuation of that on which the Glandore iron and manganese mine was worked, two miles to the west. It has an east and west direction, and traverses brown micaceous sandstones and very pale, often

almost white, talc-schists of Devonian age. The vein-filling consists principally of limonite and shattered quartz, much of the former being botryoidal and beautifully iridescent; psilomelane and pyrolusite are also present in smaller quantity. The mine was worked on a small scale apparently at the same time as, and in conjunction with, that of Glandore between the years 1843 and 1854, while about 1906 it was partially re-prospected.

The specimen in question consists of a small mass $4\frac{1}{2} \times 3\frac{1}{2}$ cm. of diverging fibrous crystals of a reddish-brown colour, the fibres extending from walls of pitchy black limonite and meeting in the centre, a certain amount of limonite being also present between the fibres. The fibres attain a length of 1 cm., are readily divisible, and many of them when viewed singly under a lens are seen to be transparent, and of a beautiful dark hyacinth-red colour. The mineral exactly resembles, though on a larger scale, certain radiated specimens of the variety of beraunite from the Rothläufchen mine, Waldgirmes, Hesse, Germany, to which the name eleonorite has been given. The fibres are elongated in the direction of the *b*-axis, and are strongly pleochroic, red-brown for vibrations parallel to *b*, and yellow in the transverse direction. The refractive index is 1.78, and the specific gravity 2.99. The mineral is soluble in hydrochloric acid. Before the blowpipe it fuses easily to a crystalline black metallic-looking bead. A qualitative analysis gave ferric iron, phosphoric acid, and water.

Beraunite was mentioned from Wheal Jane, Kenwyn, Cornwall, by R. P. Greg¹ in 1860; the mineral, which accompanied vivianite, was later, however, analysed by A. H. Church,² and shown to be a variety of hisingerite. It is therefore satisfactory to be able to re-establish this species as occurring in the British Isles.

¹ R. P. Greg, *Phil. Mag.*, 1860, ser. 4, vol. 19, p. 14.

² A. H. Church, *Journ. Chem. Soc. London*, 1870, vol. 23, p. 3. In Dana's *System of Mineralogy*, 6th edit., 1892, p. 703, the locality is incorrectly given as Lostwithiel.

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There are four meetings of the Society each year, on Tuesdays at 5.30 p.m. in January, March, June, and November. They are held (by kind permission) in the Apartments of the Geological Society, Burlington House, Piccadilly, London, W.1. Titles of papers to be read at these meetings, with a view to subsequent publication in the Magazine, should be sent to the General Secretary at least two weeks before the meeting. Authors alone are responsible for the views set forth in their respective papers. They are allowed, free of charge, fifty separate copies of their papers published in the Magazine.

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